Vierendeel.

نسألكم الدعاء

IF you download the Free ***APP.*** RC Structures YASSER EL LEATHY *on your smart phone or tablet, you will be able to play illustrative movies For any paragraph that has a QR code icon*

اذا حملت تطبيق RC Structures YASSER EL LEATHY على تليفونك المحمول او اللوح السطحى ستستطيع أن تشغل أفلام شرح للمقاطع التى تحتوى على رمز

Vierendeel. Table of Contents.

Introduction.

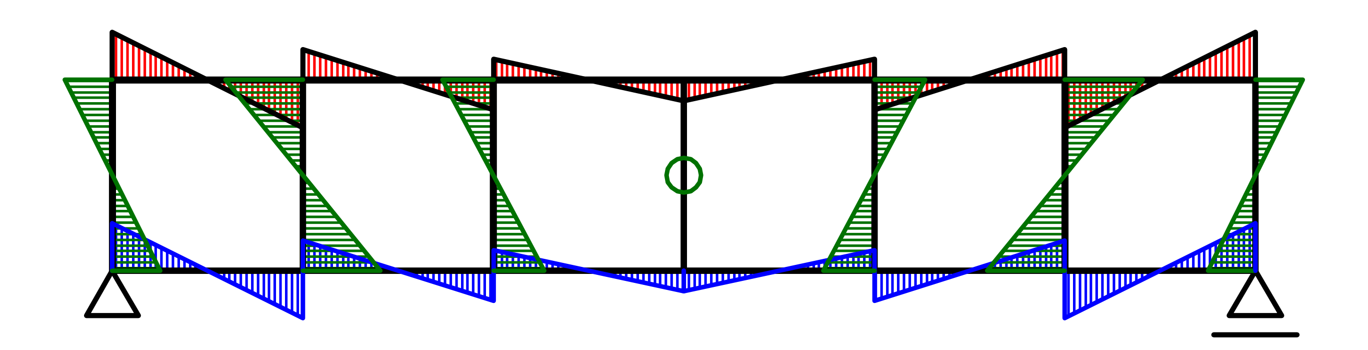


$h = \frac{L}{6 \rightarrow 8}$

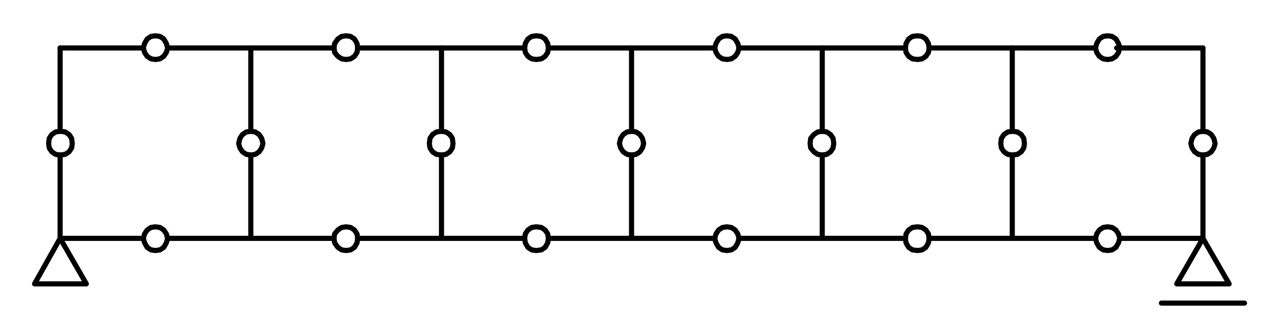
H

$L = (15 \rightarrow 40)\, m$

B.M.D.

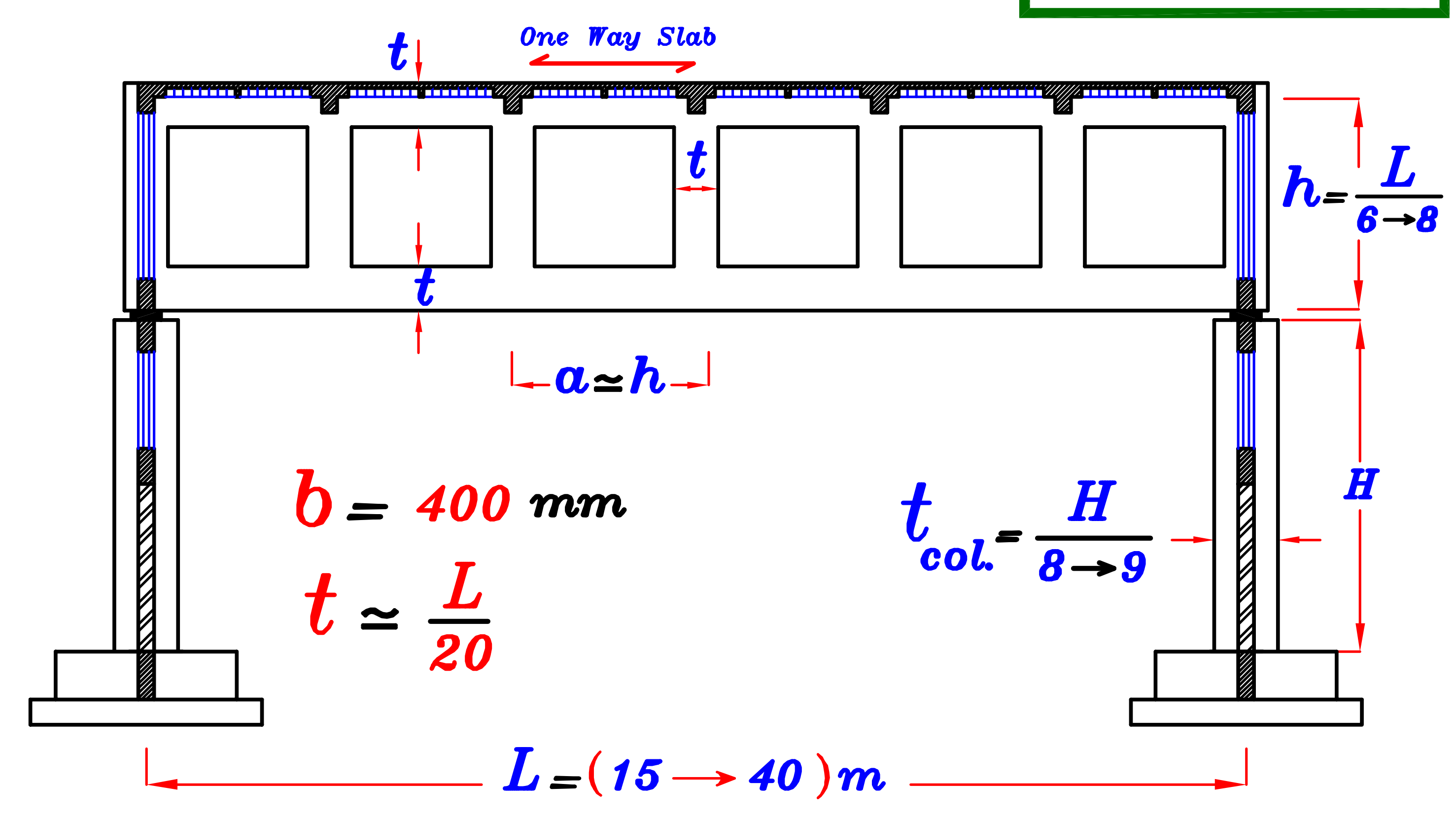


Statical System.



Concrete Dimensions.

يحمل سقف واحد



يحمل عده أدوار

t
t
t
h
$a \simeq h$
$t_{col.}$
H

$b = 600$ mm

$t_{(Vierendeel)} \simeq \frac{L}{10 \to 12}$

$h =$ Floor Height

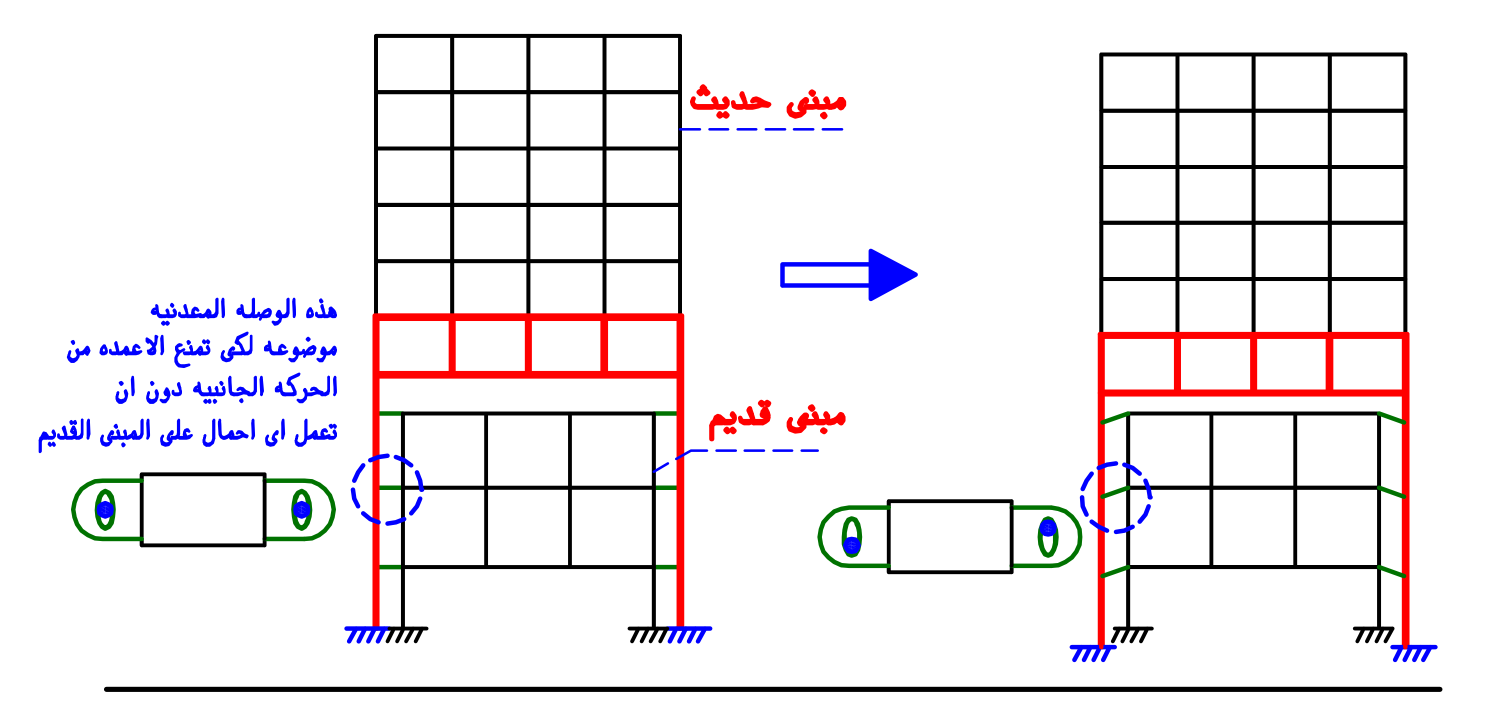
$t_{col.} \simeq t_{(Vierendeel)}$

Vierendeel Applications.

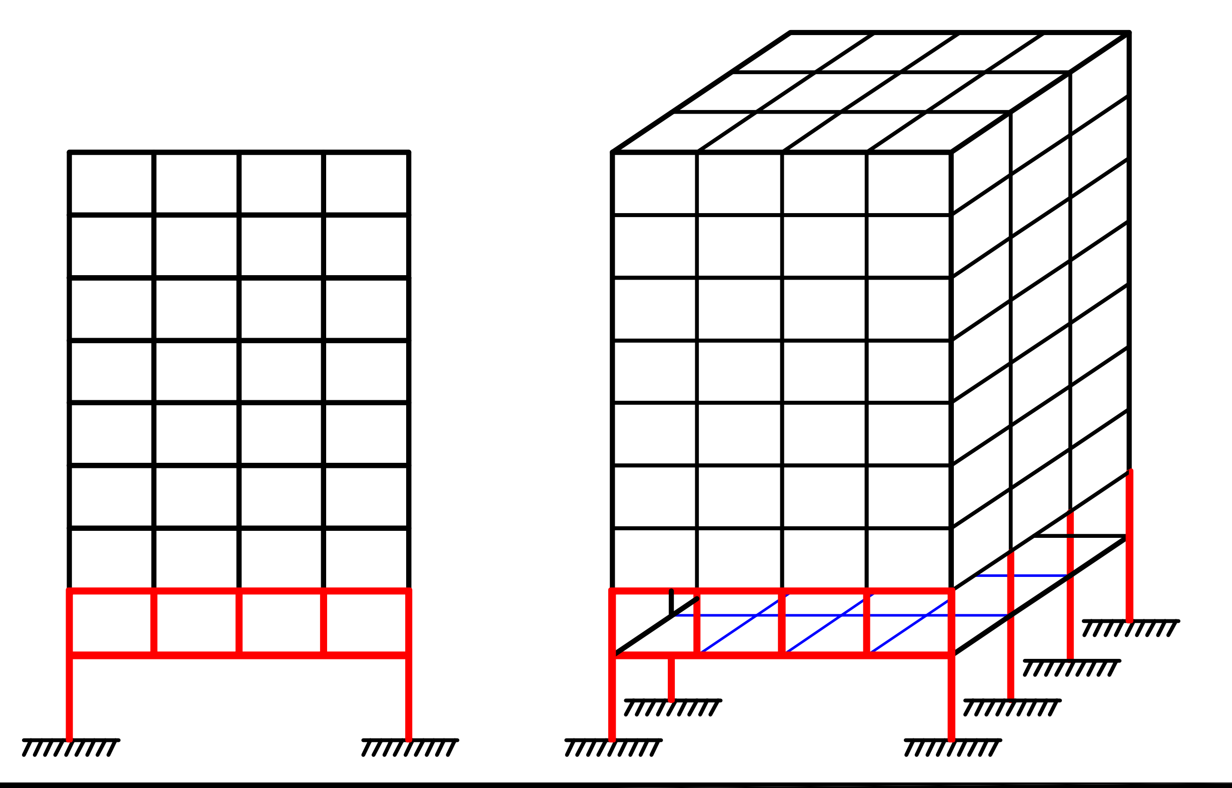
أهم إستخدامات الـ Vierendeels

يتميز الـ Vierendeels أنه يستطيع أن يحمل عدد من أدوار المبنى فوقه دون وضع أعمده فى المنتصف .

المبنى الحديث محمول على Vierendeels
و الـ Vierendeels محموله على أعمده خارجيه دون أن يحمل على المبنى القديم

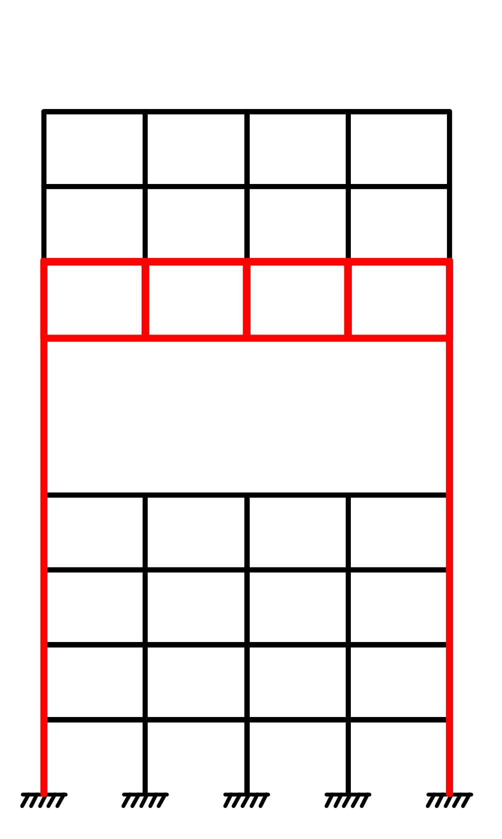


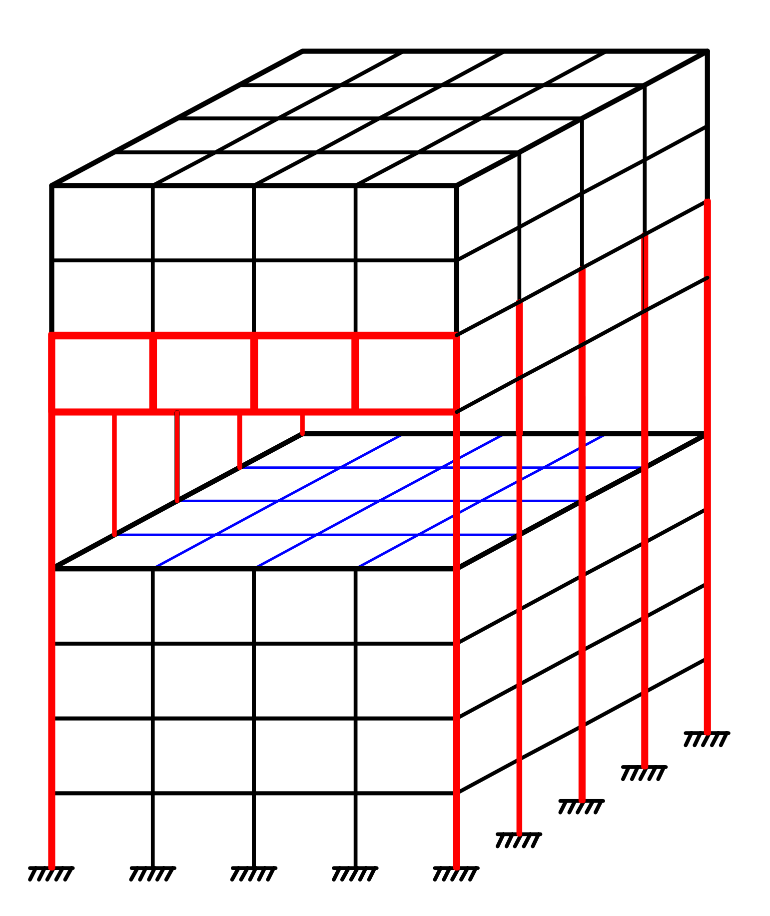
لا توجد أعمده فى الدور الارضى لان كل الادوارالعلويه محموله على Vierendeels
و الـ Vierendeels محموله على أعمده خارجيه فقط.

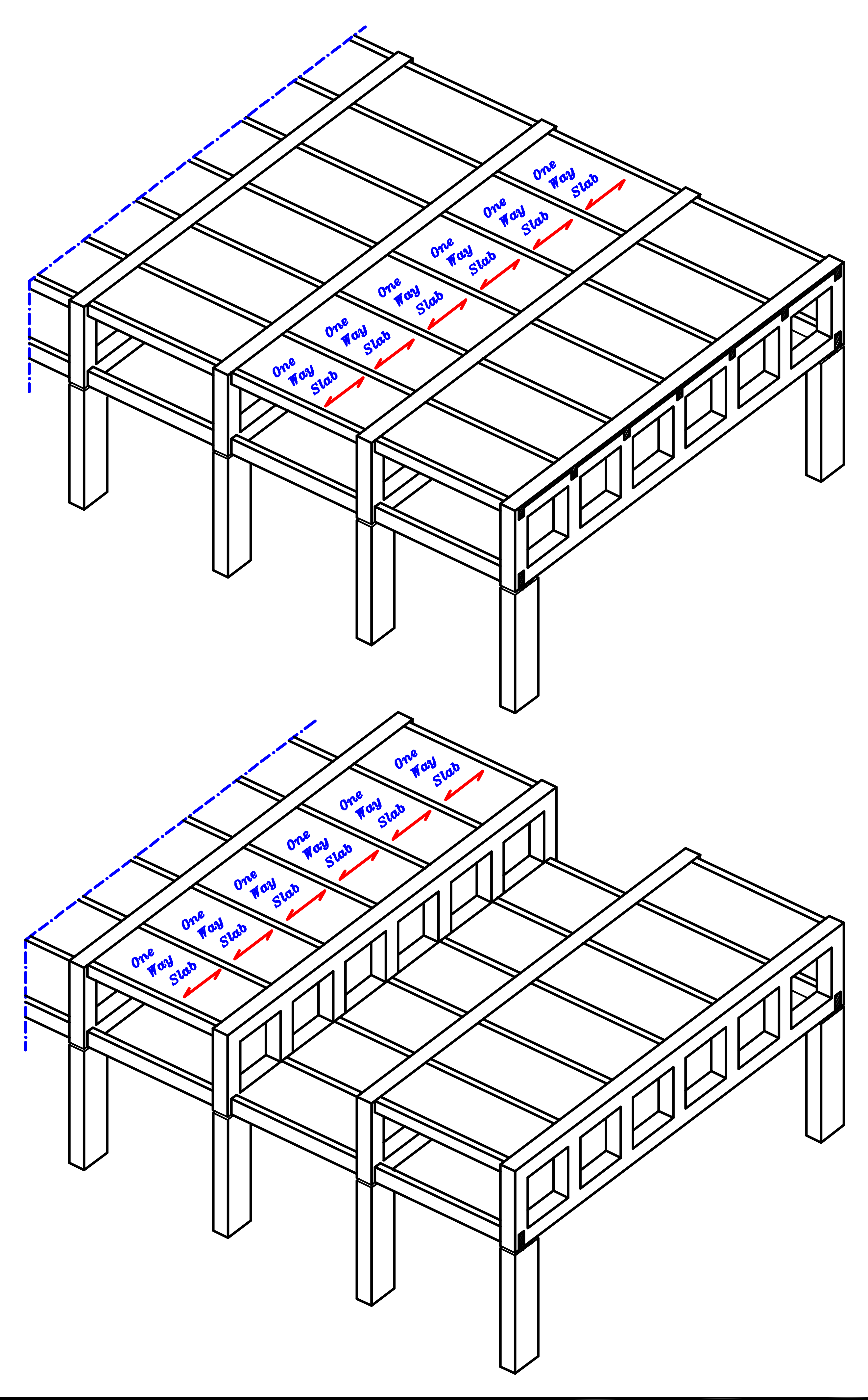


توجد قاعه بدون أعمده داخليه فى الدور الخامس

و الادوار العلويه محموله على *Vierendeels* فى الدور الخامس و ال *Vierendeels* محموله على أعمده خارجيه .






One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab
One Way Slab

Analysis of Vierendeel.

We have Two methods to solve the Vierendeel.

① Exact Method.

Using Computer

One way OR Two way في هذه الطريقه ممكن أخذ البلاطات

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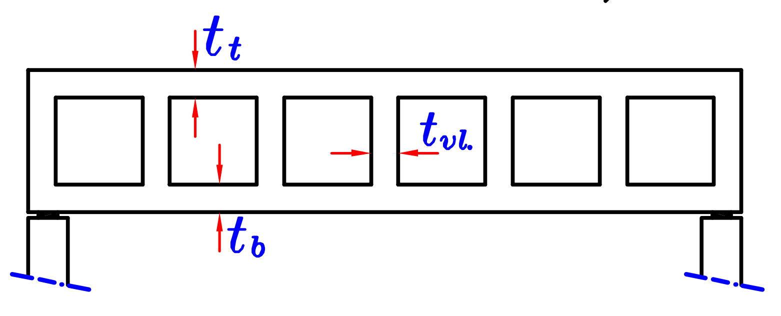
② Approximate Method.

To solve by this method we have to take

1_ Take the slabs one way (at beam direction)

2- $t_t = t_b$

3- $t_{vl.}$ is Constant.



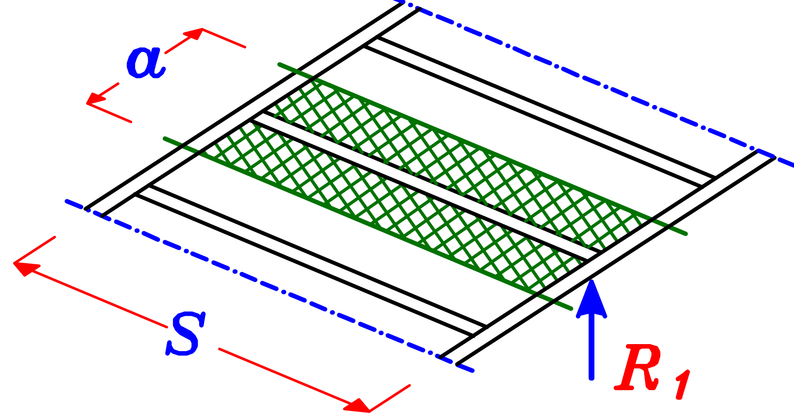
Calculation of Loads on Viernedeel.

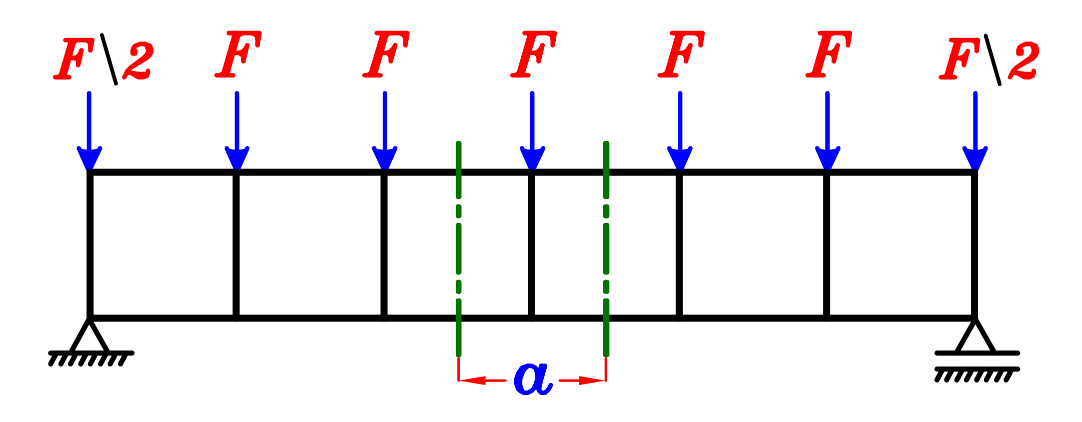
توجد طريقتان لحساب الاحمال على ال Vierendeel

١- assume O.W.(Vierendeel) ≃ 25.0 kN\m` (U.L.)

$w_1 = O.W._{(beam)} + w_S * a$

$R_1 = w_1 * S$





$$F = O.W._{(Vierendeel)} * a + R_1 * n$$

عدد الادوار

-٢

Floor area

Plan

- Assume the total equivalant working loads is

$$w_{av\,(U.L.)} = (12.0 \rightarrow 15.0)\ kN/m^2$$

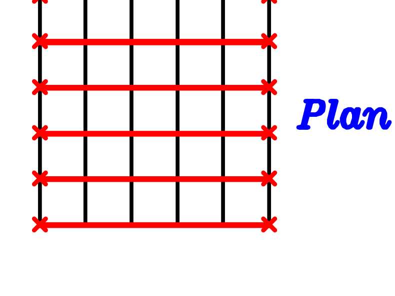
- Total Load For one Floor $= w_{av} *$ Floor area

Elev.

- Total Load For the building

يتم زياده وزن سقف الدور الارضى .

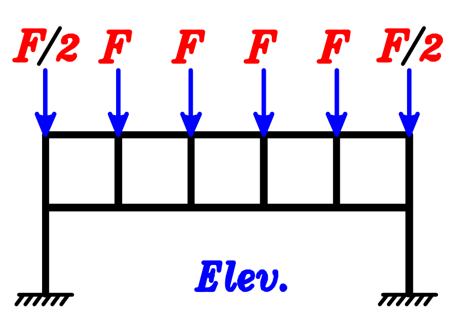
= Load of one Floor * No. of Floors.



- Total Load on One Vierendeel.

يتم توزيع الحمل الكلي على عدد الـ Vierendeels

مع فرض أن أول و أخر system سيحمل نصف الحمل فقط.

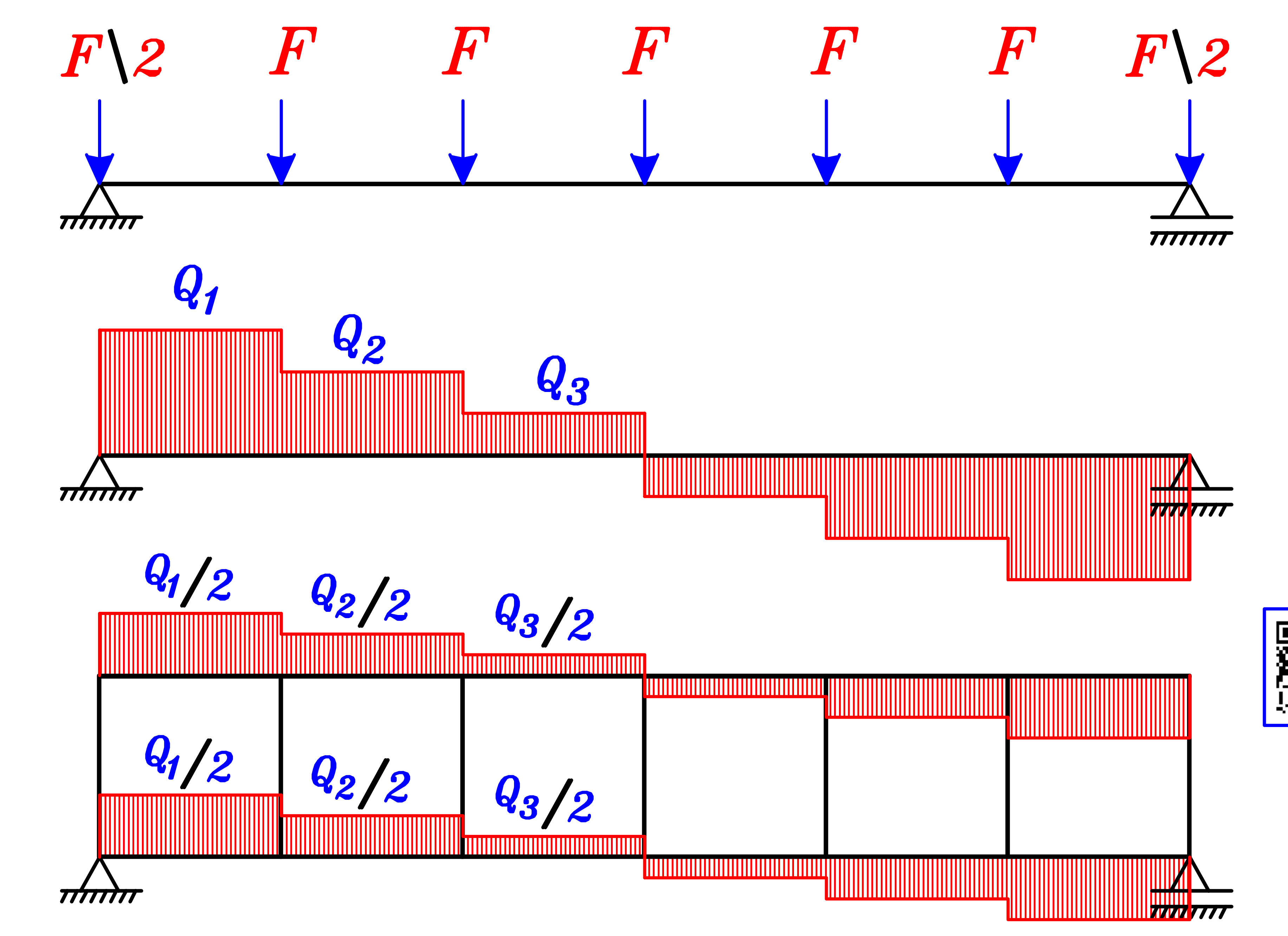


- Load on one joint of the Vierendeel.

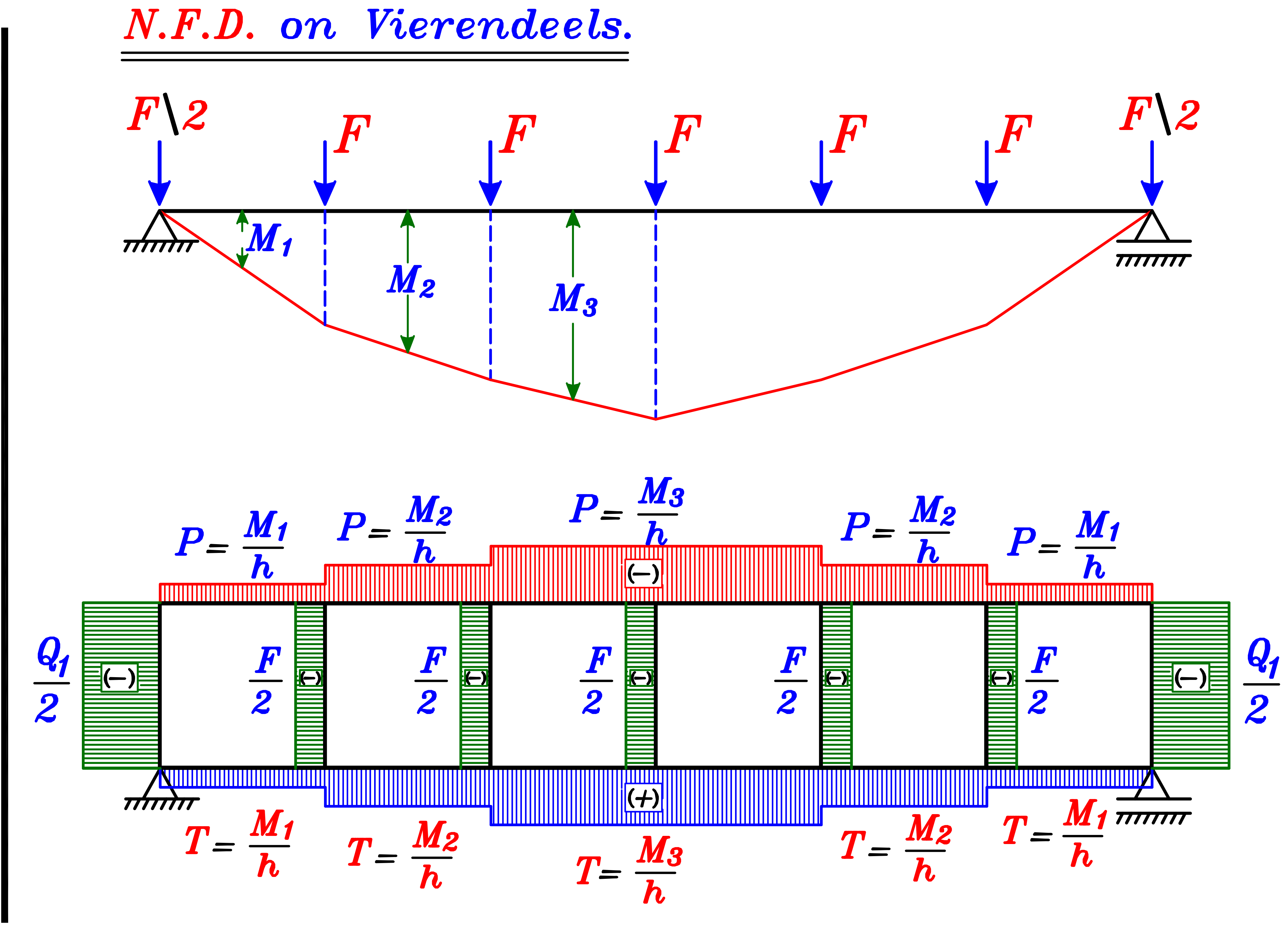
يتم توزيع الحمل الكلي للـ Vierendeels على عدد الـ joints

مع فرض أن أول و أخر joint ستحمل نصف الحمل فقط

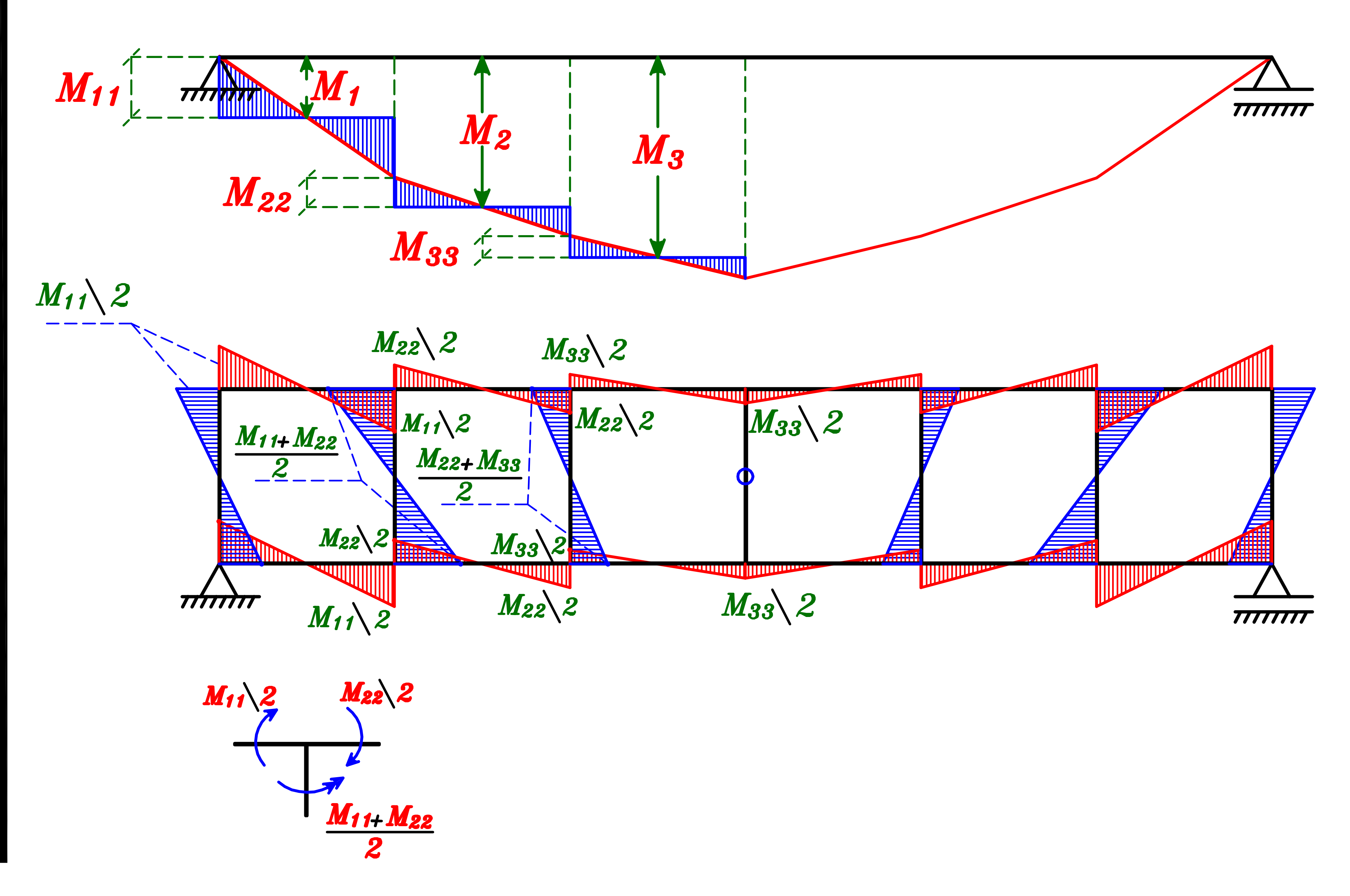
S.F.D. on Vierendeels.



N.F.D. on Vierendeels.



B.M.D. on Vierendeels.



Drawing RFT. of Vierendeel.

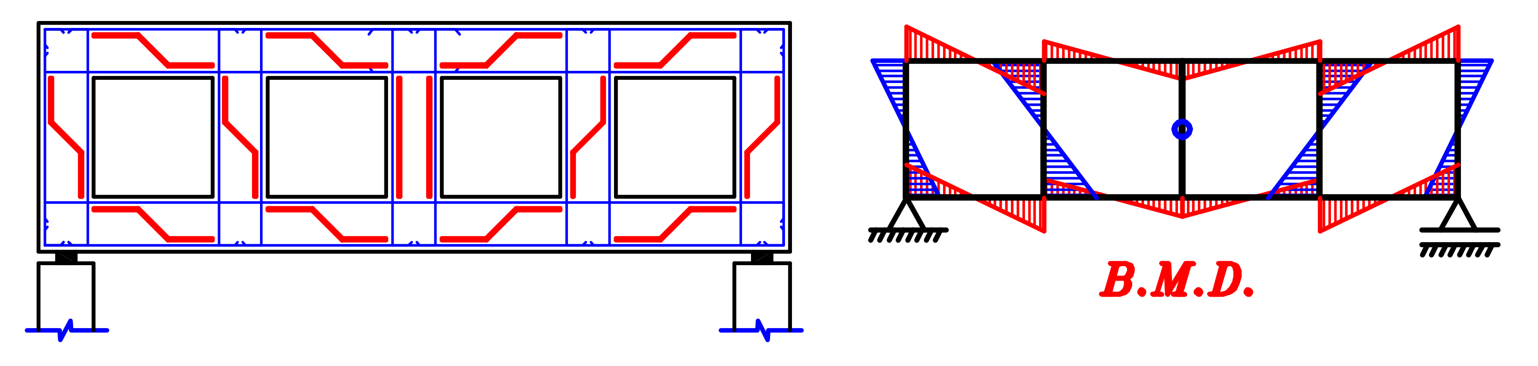


١- نبداء برسم نصف التسليح مع مراعاه ان الحديد ناحيه الشد يكمل
و الحديد ناحيه الضغط يمتد كل باكيتين و بعدها يمتد L_d

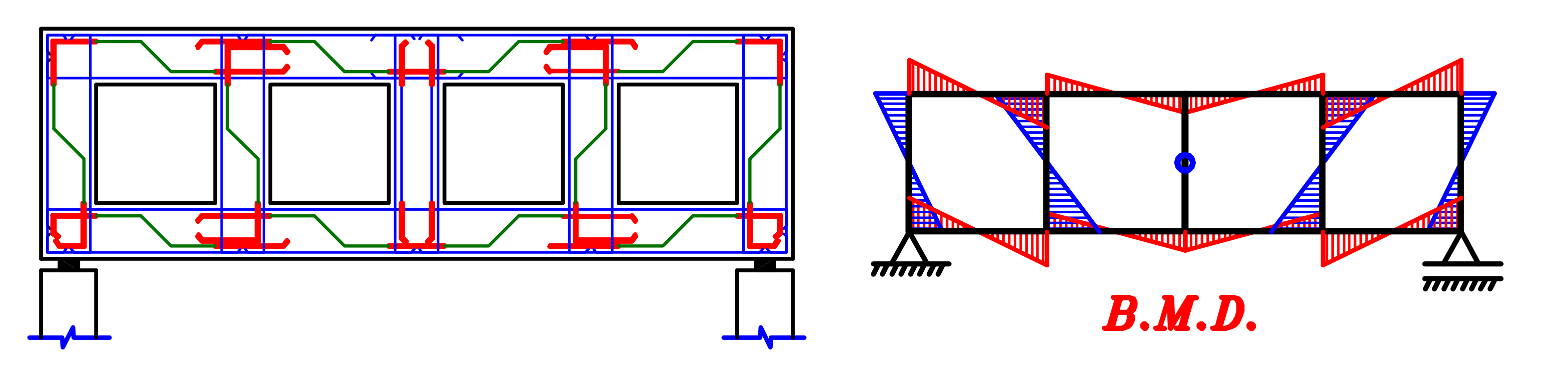
Compression
L_d L_d
Tension

N.F.D.
(−)
(+)

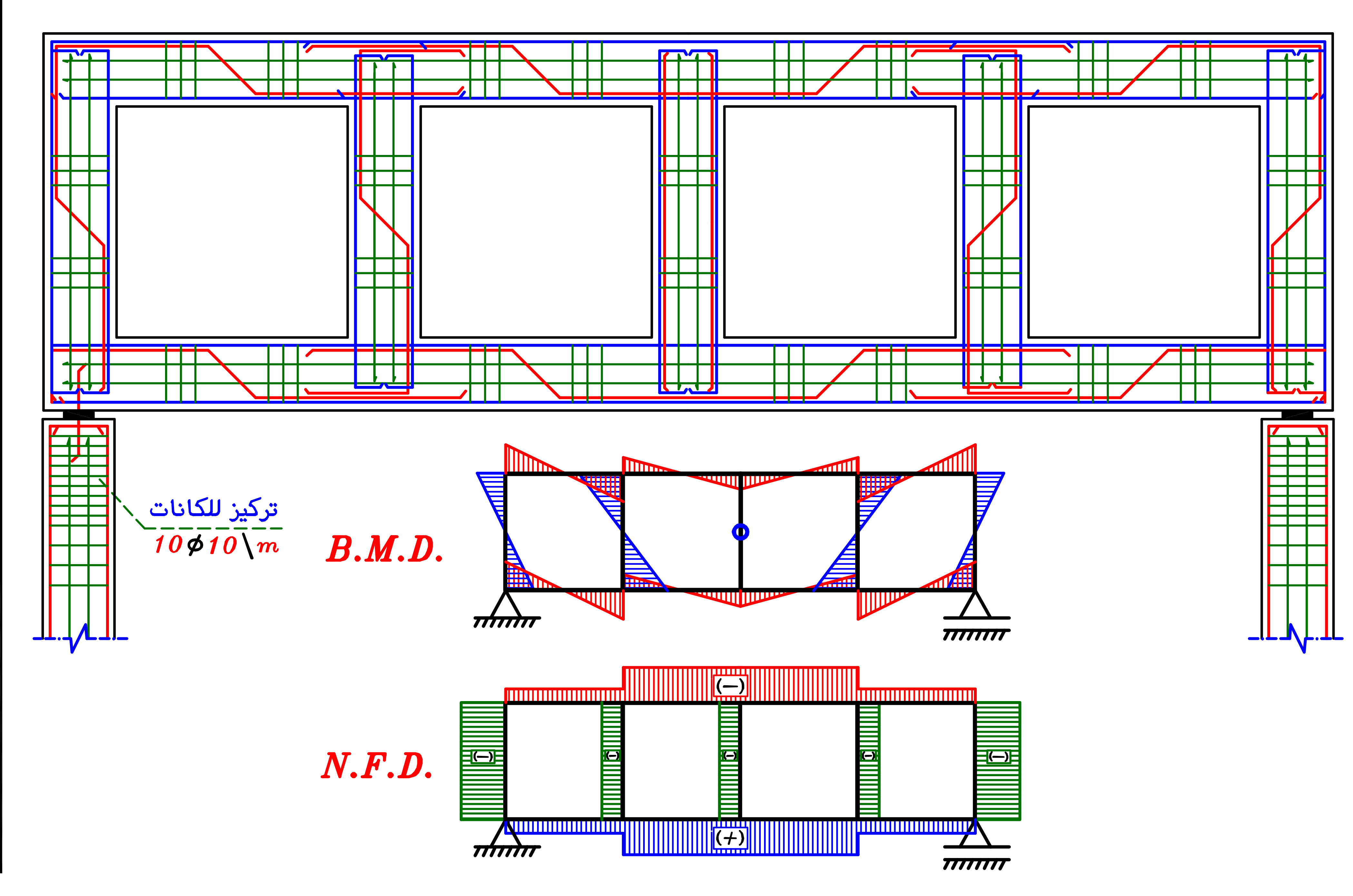
٢- نرسم النصف الاخر من التسليح ناحيه العزم و نكسحه عند منتصف ال member

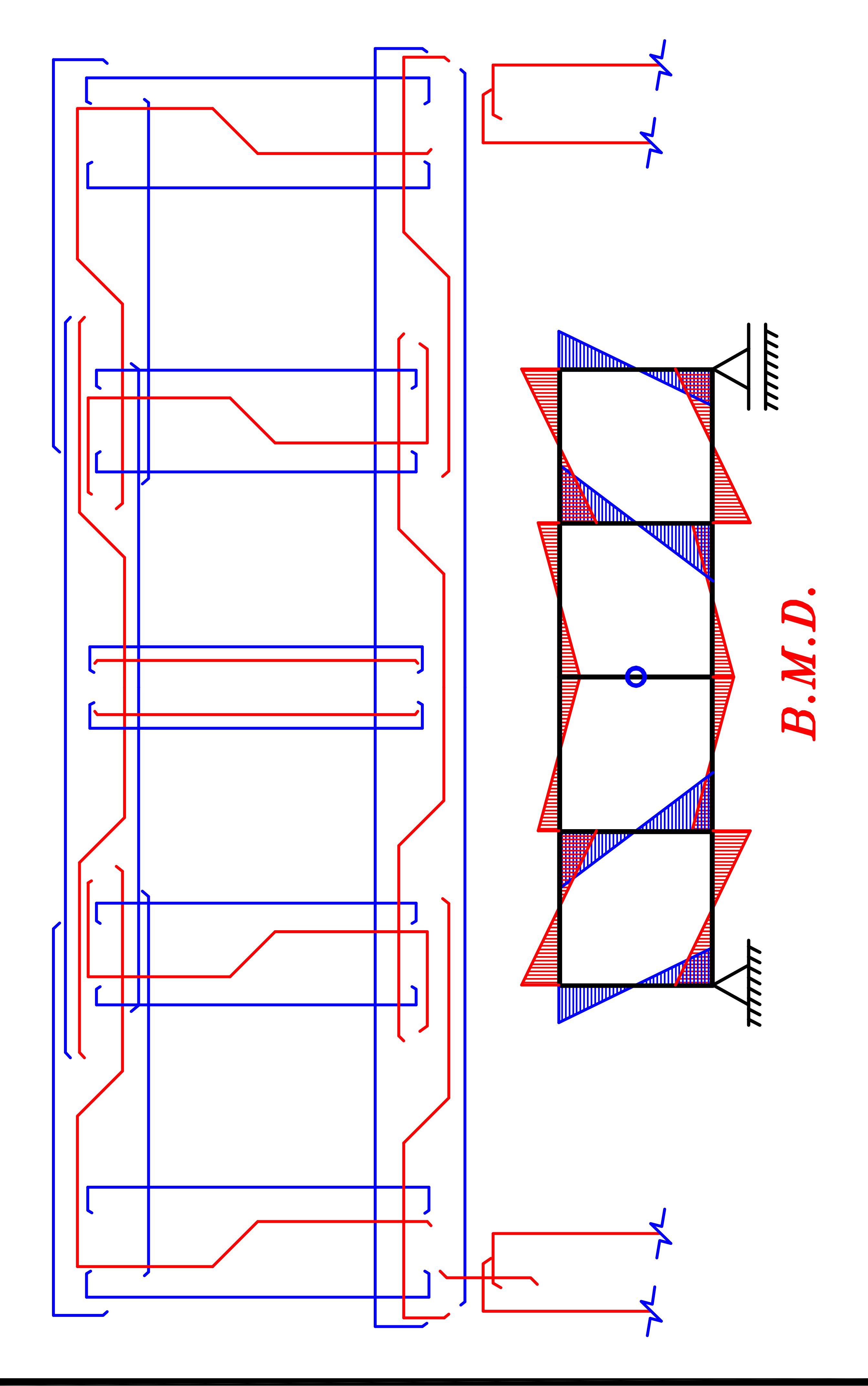


٣- نمد التسليح المكسح بعد نهايه كل member مسافه L_d

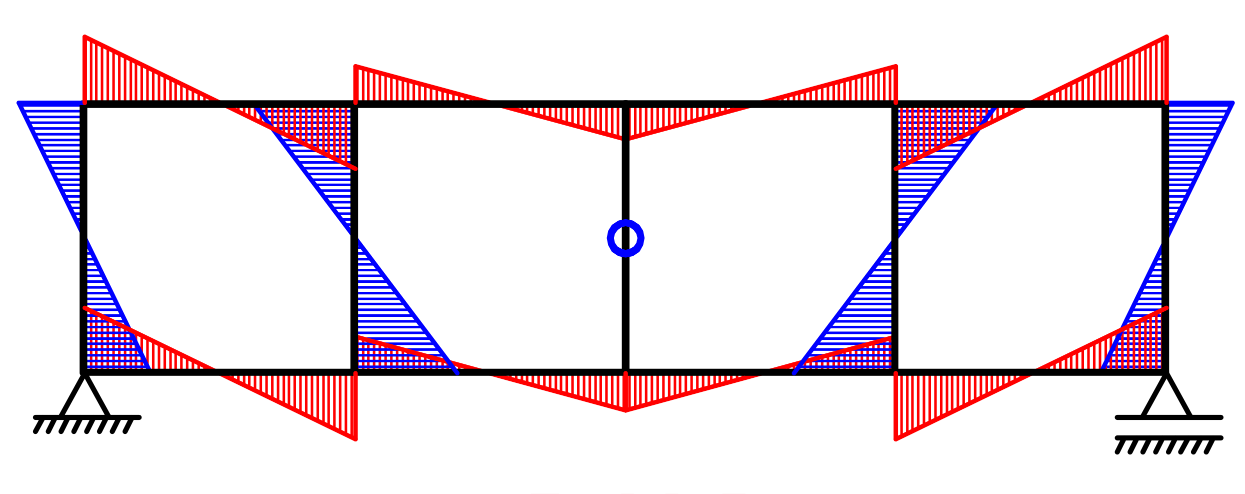


RFT. of the Vierendeel.



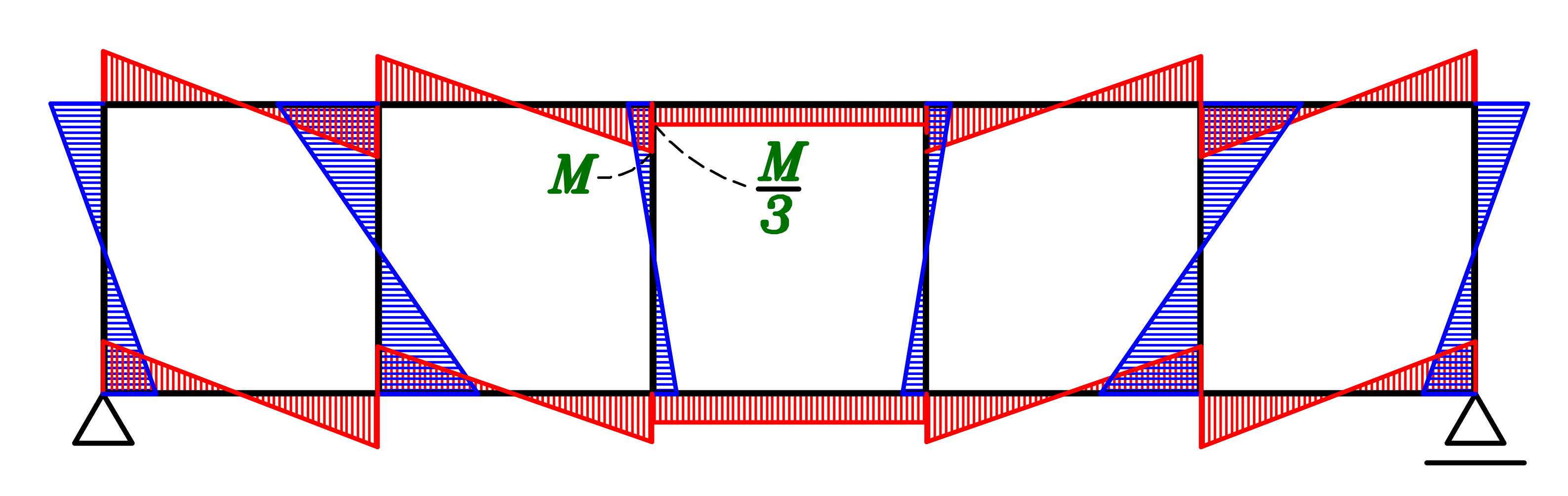

B.M.D.

4 Segments.

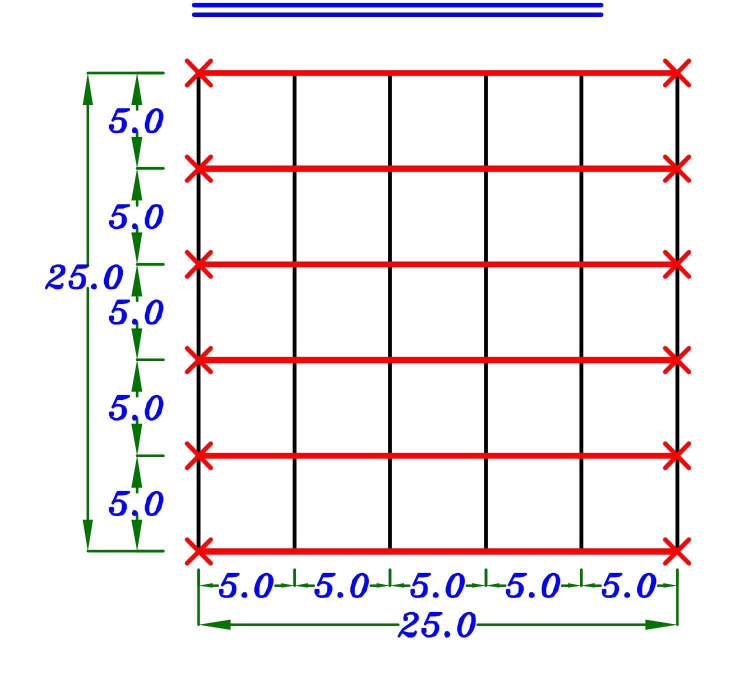


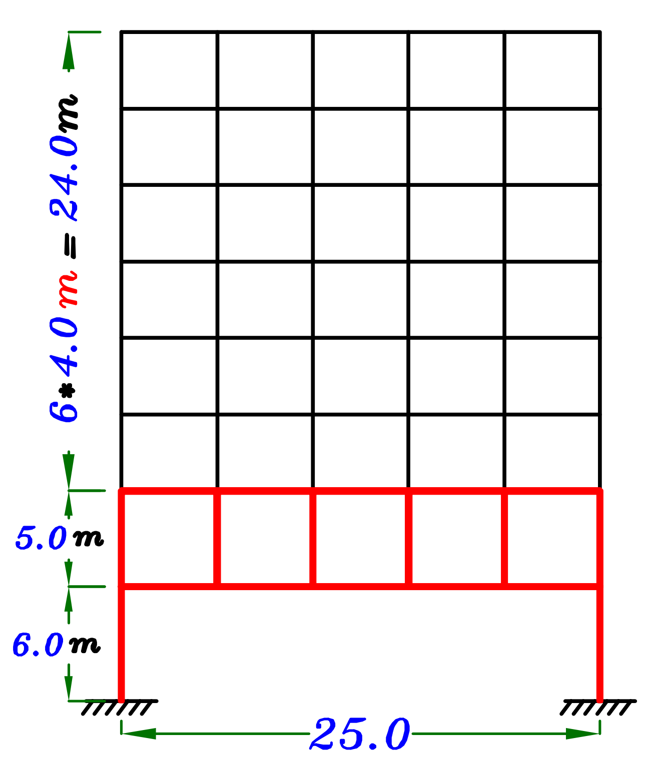
B.M.D.

5 Segments.



Example.





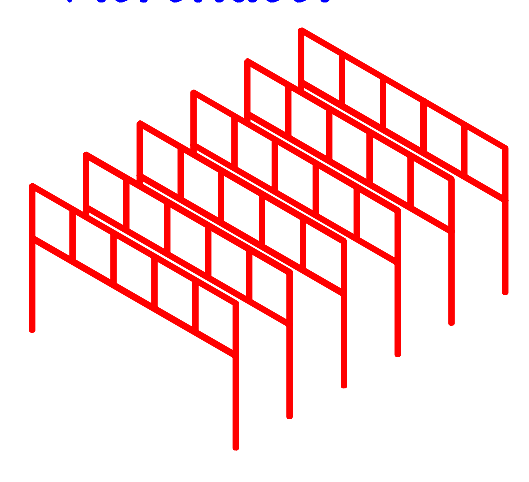
For the given Figure shows a layout of a building of an area **25.0 * 25.0** m^2
The building consists of ground Floor and Seven typical Floor.
The interior columns are removed at the ground Floor.
The total equivalent working loads is **10.0** kN/m^2

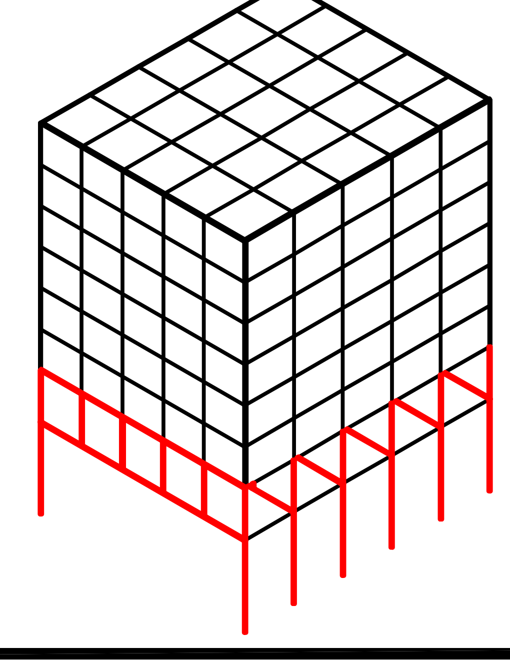
$F_{cu} = 30 \ N \backslash mm^2$, $F_y = 360 \ N \backslash mm^2$

It is required to:

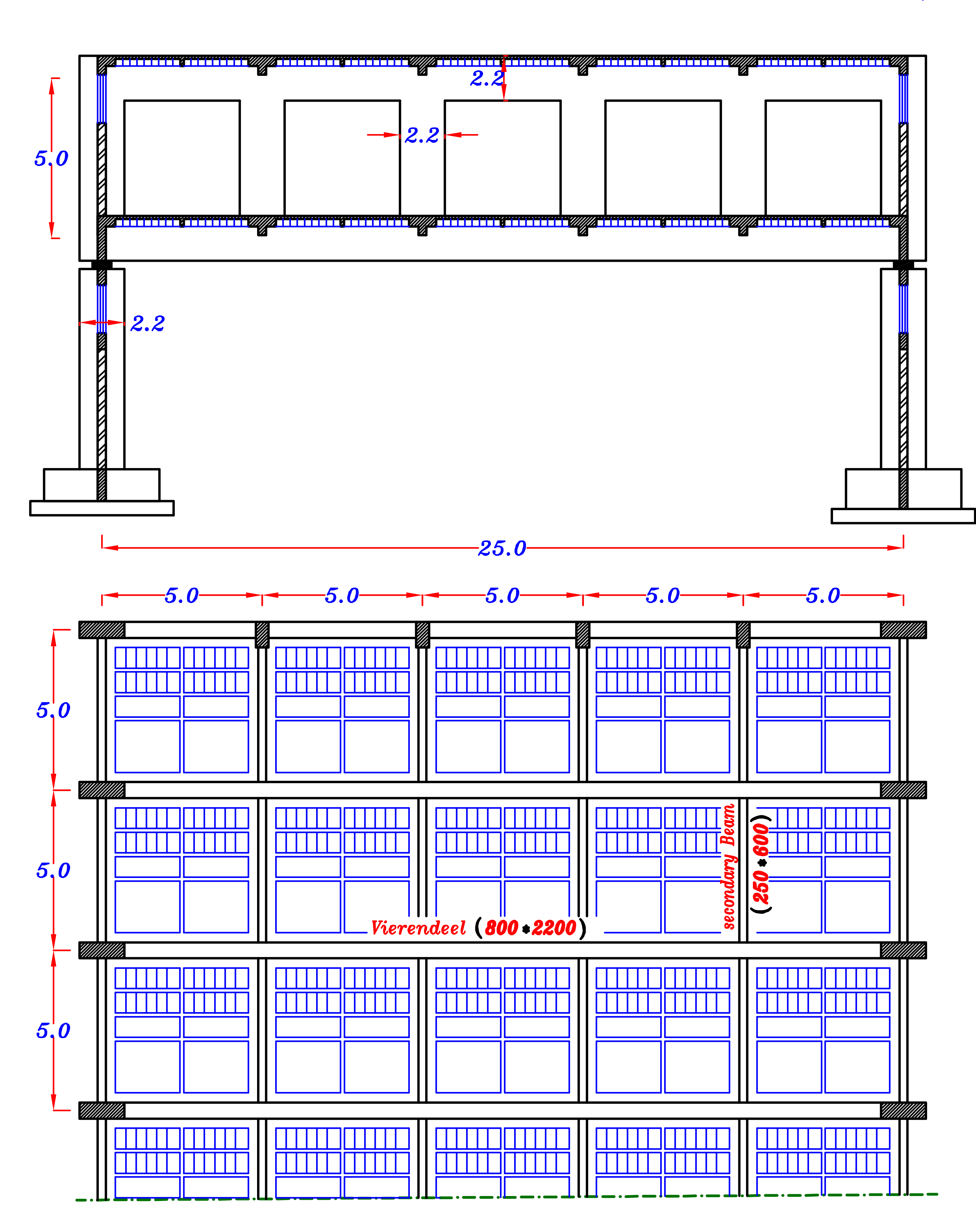
1. Choose a reasonable structural system For the ground Floor and draw its Concrete dimensions in plan and elevation to scale **1:50**
2. Calculate the Loads on the main supporting element.
3. Draw Internal Forces Diagrams For the main supporting element.
4. Design the main supporting element.
5. Draw details of RFT. of the main supporting element in elevation and cross sections to scale **1:25**

Vierendeel





1 – Take the main supporting element Vierendeel (800 * 2200)

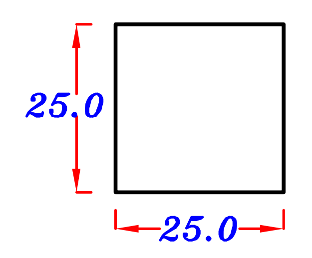


2 – Calculate the Loads on the main supporting element.

The total equivalent working loads is 10.0 kN/m^2

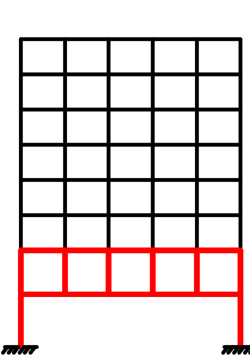
– $w_{av\,(U.L.)} = 10.0 * 1.5 = 15.0\ kN/m^2$

– Total Load For one Floor $= w_{av} *$ Floor area



$= 15.0 * 25.0 * 25.0 = 9375\ kN$

– Total Load For the building

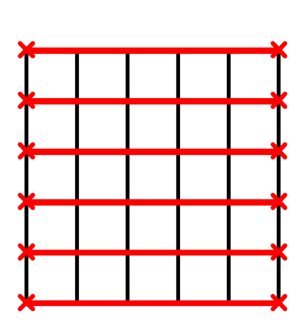


يتم زياده وزن سقف الدور الارضى .

$=$ Load of one Floor * No. of Floors.

$= 9375 * 8.0 = 75000\ kN$

– Total Load on One Vierendeel.

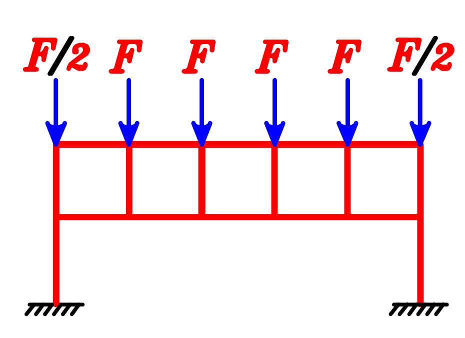


يتم توزيع الحمل الكلى على عدد ال Vierendeels

مع فرض أن أول و أخر system سيحمل نصف الحمل فقط.

Total Load on One Vierendeel.

$$= \frac{75000\ kN}{5.0} = 15000\ kN$$



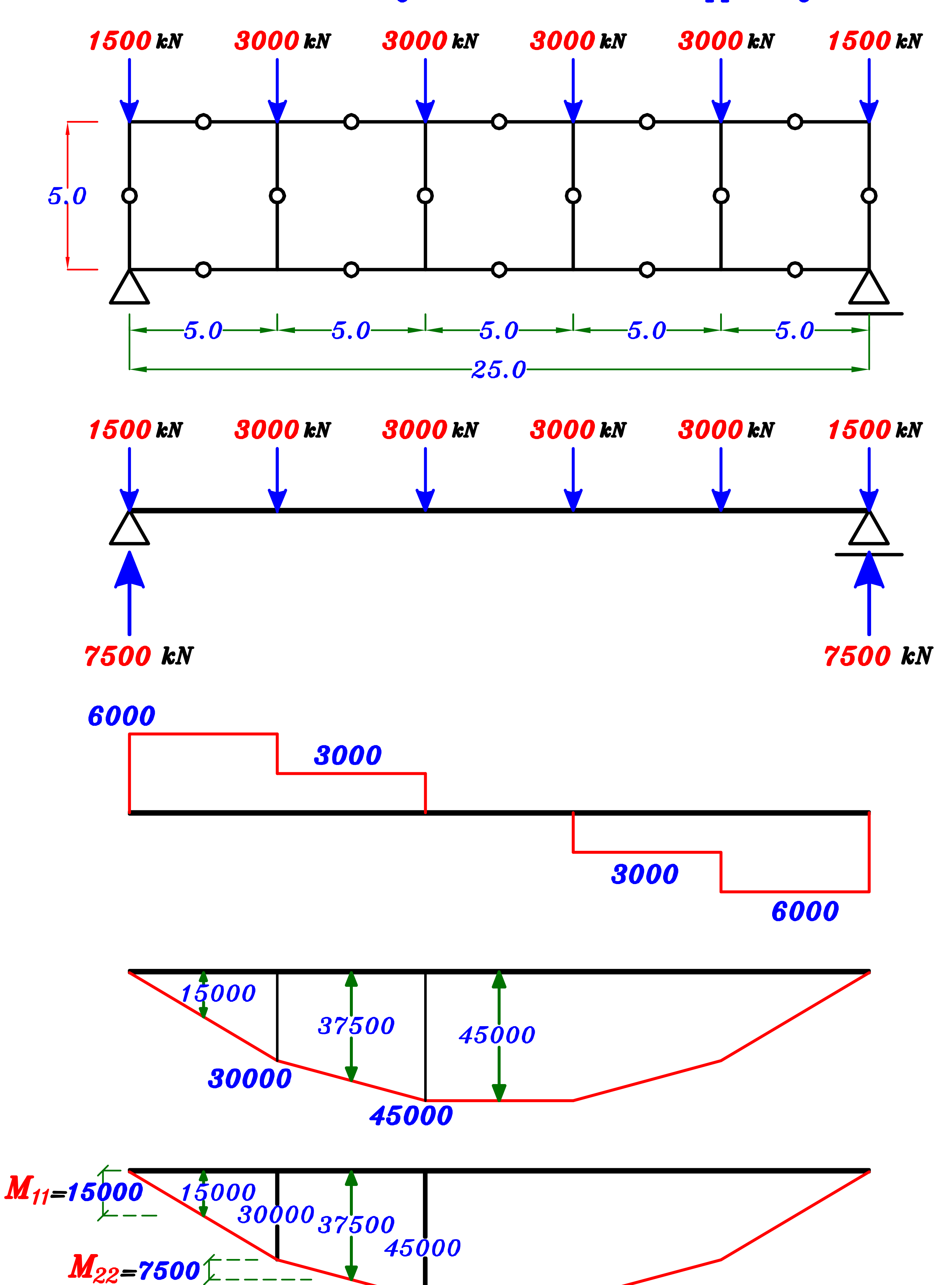
– Load on one joint of the Vierendeel.

يتم توزيع الحمل الكلى للـ Vierendeels على عدد ال joints

مع فرض أن أول و أخر joint ستحمل نصف الحمل فقط

$$F = \frac{15000}{5.0}\ kN = 3000\ kN \quad (U.L.)$$

3 – Draw Internal Forces Diagrams For the main supporting element.



N.F.D. on Vierendeel.

N.F.D.

B.M.D. on Vierendeel.

B.M.D.

Design of sections.

Sec. ① R–Sec.

$M = 11250$ kN.m , $P = 1500$ kN , $b = 800$ mm , $t = 2200$ mm

Check $\frac{P}{F_{cu}\, b t} = \frac{1500 * 10^3}{30 * 800 * 2200} = 0.028 < 0.04$ (Neglect P)

$$2100 = C_1 \sqrt{\frac{11250 * 10^6}{30 * 800}} \longrightarrow C_1 = 3.06 \longrightarrow J = 0.747$$

$$A_s = \frac{M_{U.L.}}{J\, F_y\, d} = \frac{11250 * 10^6}{0.747 * 360 * 2100} = 19920\ mm^2$$

Check $A_{s\,min.}$ $A_{s_{req.}} = 19920\ mm^2$

$$\mu_{min.}\, b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{30}}{360}\right) 800 * 2100 = 5751.1\ mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.}\, b\, d$ $\therefore$ Take $A_s = A_{s_{req.}} = 19920\ mm^2$ **26 ϕ32**

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{800 - 25}{32 + 25} = 13.6 = 13.0 \text{ bars}$$

Sec. ② R–Sec.

$M = 7500$ kN.m , $P = 3000$ kN , $b = 800$ mm , $t = 2200$ mm

Check $\frac{P}{F_{cu}\, b t} = \frac{3000 * 10^3}{30 * 800 * 2200} = 0.056 > 0.04$ (Don't Neglect P)

$$e = \frac{M}{P} = \frac{7500}{3000} = 2.50\ m \quad \therefore \frac{e}{t} = \frac{2.50}{2.2} = 1.13\ m > 0.5 \xrightarrow{use} e_s$$

$$e_s = e + \frac{t}{2} - c = 2.50 + \frac{2.2}{2} - 0.1 = 3.50\ m$$

$$M_s = P * e_s = 3000 * 3.50 = 10500 \ kN.m$$

$$2100 = C_1 \sqrt{\frac{10500 * 10^6}{30 * 800}} \longrightarrow C_1 = 3.17 \longrightarrow J = 0.757$$

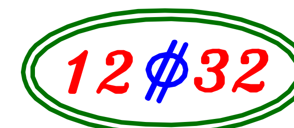
$$A_s = \frac{M_s}{J F_y d} - \frac{P_{U.L.}}{(F_y \backslash \delta_s)} = \frac{10500 * 10^6}{0.757 * 360 * 2100} - \frac{3000 * 10^3}{(360 \backslash 1.15)}$$

$$= 8764 \ mm^2$$

Check $A_{s\,min.}$ $A_{s_{req.}} = 8764 \ mm^2$

$$\mu_{min.} b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{30}}{360}\right) 800 * 2100 = 5751.1 \ mm^2$$

$\therefore A_{s_{req.}} > \mu_{min.} b\, d \quad \therefore$ Take $A_s = A_{s_{req.}} = 8764 \ mm^2$



Sec. ③ R-Sec.

$M = 7500 \ kN.m$, $P = 1500 \ kN$, $b = 800 \ mm$, $t = 2200 \ mm$

Check $\frac{P}{F_{cu}\, b\, t} = \frac{1500 * 10^3}{30 * 800 * 2200} = 0.028 < 0.04$ (Neglect P)

$$2100 = C_1 \sqrt{\frac{7500 * 10^6}{30 * 800}} \longrightarrow C_1 = 3.75 \longrightarrow J = 0.793$$

$$A_s = \frac{M_{U.L.}}{J F_y d} = \frac{7500 * 10^6}{0.793 * 360 * 2100} = 12510 \ mm^2$$

Check $A_{s\,min.}$ $A_{s_{req.}} = 12510 \ mm^2$

$$\mu_{min.} b\, d = \left(0.225 * \frac{\sqrt{F_{cu}}}{F_y}\right) b\, d = \left(0.225 * \frac{\sqrt{30}}{360}\right) 800 * 2100 = 5751.1 \ mm^2$$

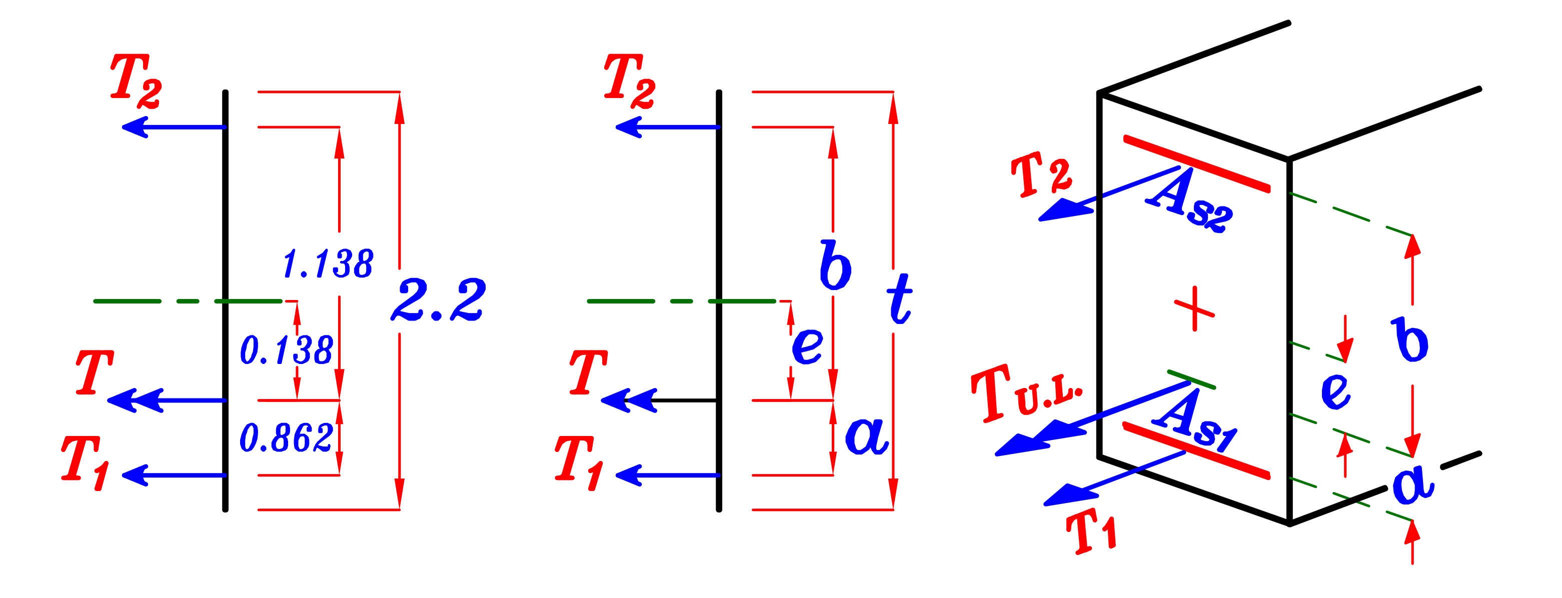
$\therefore A_{s_{req.}} > \mu_{min.} b\, d \quad \therefore$ Take $A_s = A_{s_{req.}} = 8764 \ mm^2$ **16ϕ32**

Sec. ④ R–Sec.

$M = 1250 \ kN.m \ , \ T = 9000 \ kN \ , \ b = 800 \ mm \ , \ t = 2200 \ mm$

$$e = \frac{M}{T} = \frac{1250}{9000} = 0.138 \ m$$

$$\therefore \frac{e}{t} = \frac{0.138}{2.20} = 0.062 < 0.5 \longrightarrow \text{Small Eccentricity.}$$



$$a = \frac{t}{2} - c - e = \frac{2.20}{2} - 0.10 - 0.138 = 0.862 \ m$$

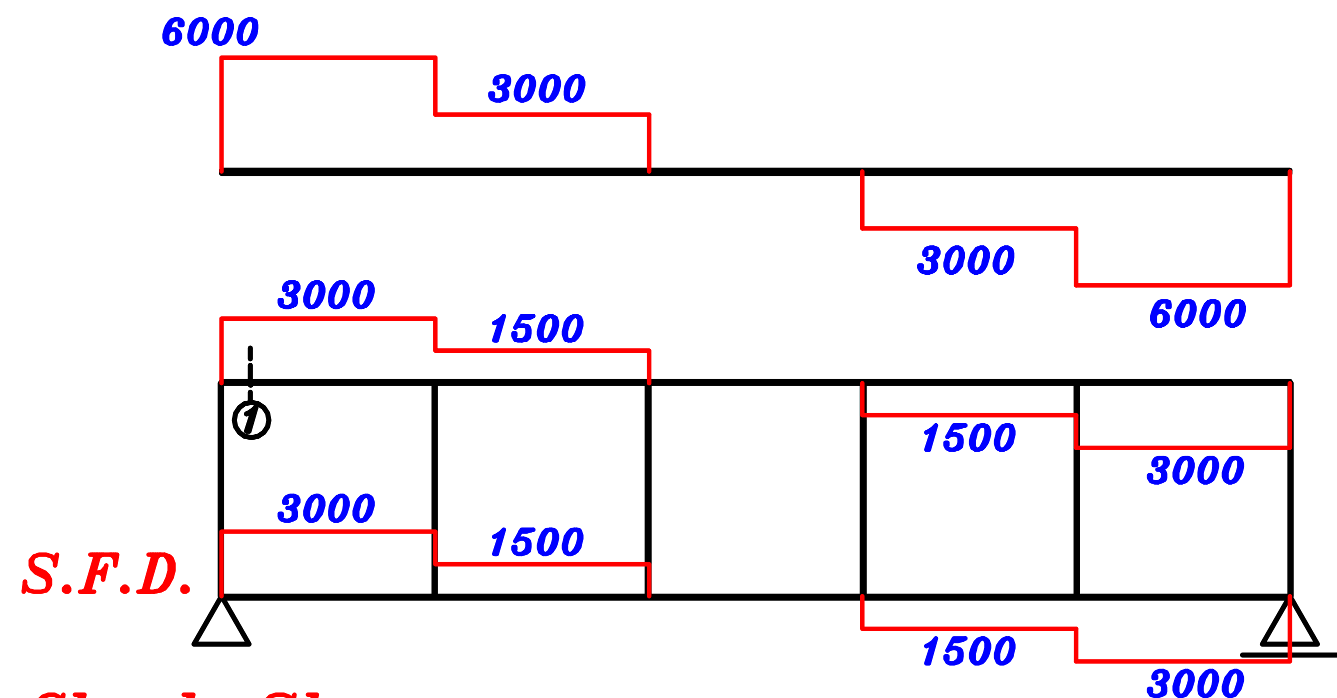
$$b = \frac{t}{2} - c + e = \frac{2.20}{2} - 0.10 + 0.138 = 1.138 \ m$$

$$T_1 = T_{U.L.}\left(\frac{b}{a+b}\right) = 9000\left(\frac{1.138}{0.862 + 1.138}\right) = 5121 \ kN$$

$$A_{s1} = \frac{T_1}{(F_y/\gamma_s)} = \frac{5121 * 10^3}{(360 \backslash 1.15)} = 16358 \ mm^2$$



S.F.D. on Vierendeels.



Check Shear.

- **Allowable shear stress.**

$$q_{cu} = 0.24\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.24\sqrt{\frac{30}{1.5}} = 1.07 \ N\backslash mm^2$$

$$q_{max.} = 0.7\sqrt{\frac{F_{cu}}{\gamma_c}} = 0.7\sqrt{\frac{30}{1.5}} = 3.13 \ N\backslash mm^2$$

Actual shear stress.

$$q_U = \frac{Q}{b\,d} = \frac{3000 * 10^3}{800 * 2100} = 1.78 \ N\backslash mm^2$$

$\therefore \ q_{cu} < q_U < q_{max.}$ $\therefore$ We need Stirrups more Than 5 ϕ8 \m`

Use Stirrups ϕ 12 steel 360/520

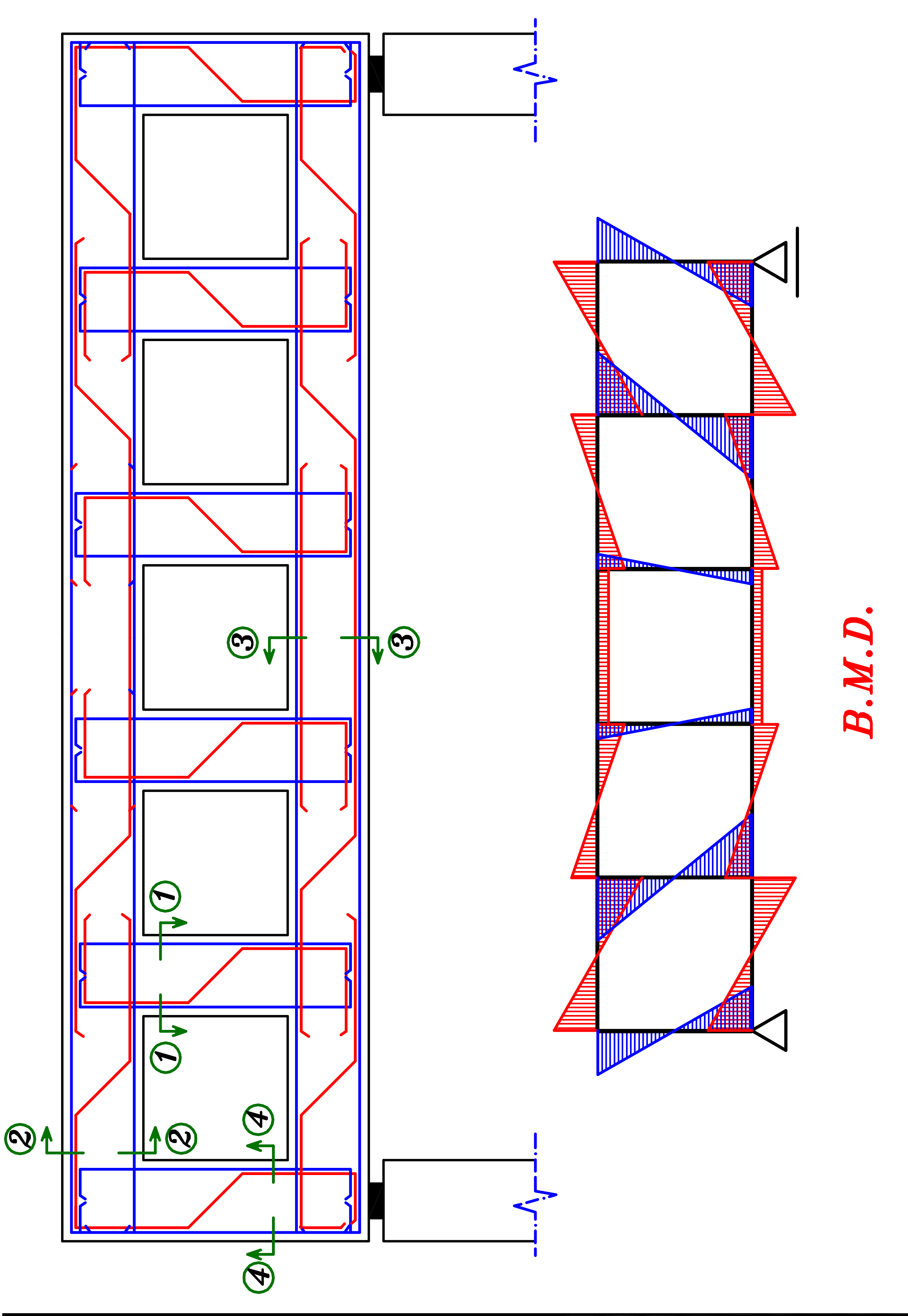
$$\therefore \text{ Use } \quad q_s = q_u - \frac{q_{cu}}{2} = \frac{n\,A_s\,(F_y\backslash\gamma_s)}{b\ \ S}$$

* Take $n = 4$, ϕ12 $\longrightarrow$ $A_s = 113 \ mm^2$

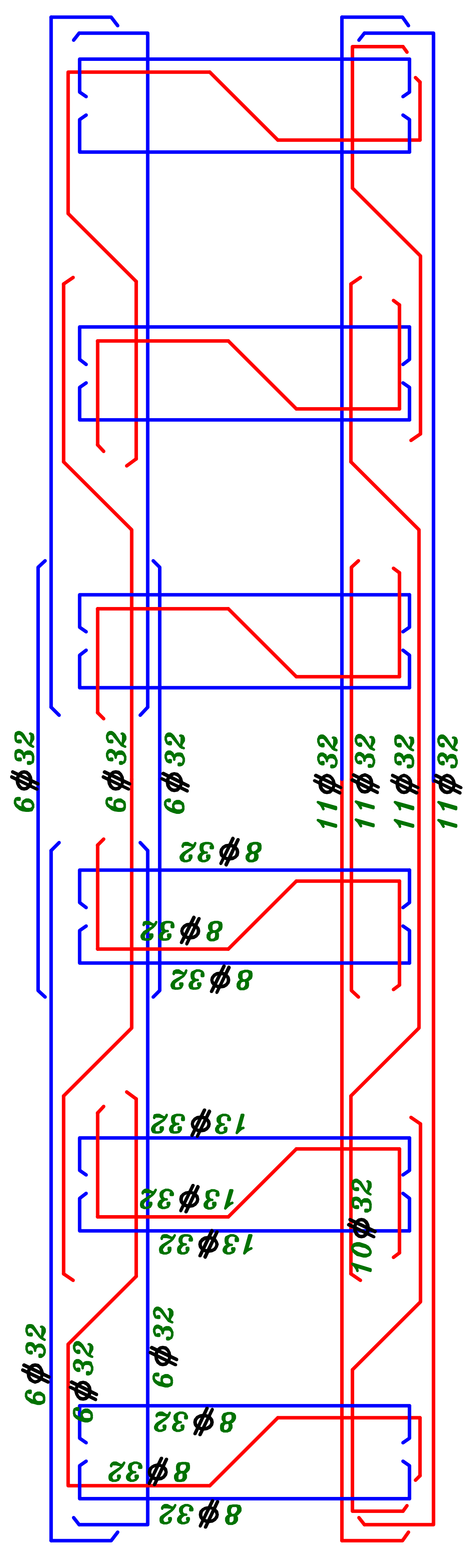
$$1.78 - \frac{1.07}{2} = \frac{4 * 113 \ (360\backslash 1.15)}{800 * S} \longrightarrow S = 142.0 \ mm > 100 \ mm$$

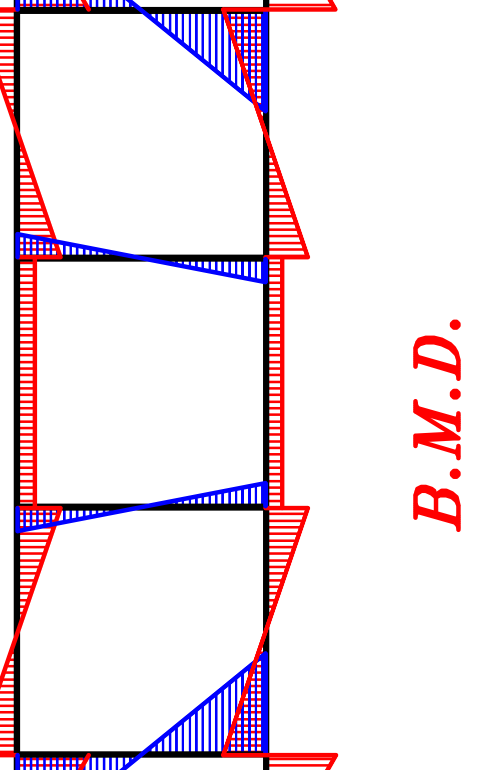
$$\therefore \text{ No. of stirrups}\backslash m` = \frac{1000}{S} = \frac{1000}{142.0} = 7.0 \ \backslash m`$$

Use Stirrups **7ϕ12\m`** 4 branches



1
1
2
2
3
3
4
4
B.M.D.


6Φ32
6Φ32
6Φ32
11Φ32
11Φ32
11Φ32
11Φ32
8Φ32
8Φ32
8Φ32
13Φ32
13Φ32
13Φ32
10Φ32
6Φ32
6Φ32
6Φ32
8Φ32
8Φ32
8Φ32


B.M.D.

800

2200

12ϕ32

6ϕ32

Sec. (2–2)

2200

800

26ϕ32

13ϕ32

Sec. (1–1)

800

2200

22ϕ32

22ϕ32

Sec. (3–3)

2200

800

8ϕ32

16ϕ32

Sec. (4–4)

Vierendeel with two cantilevers.



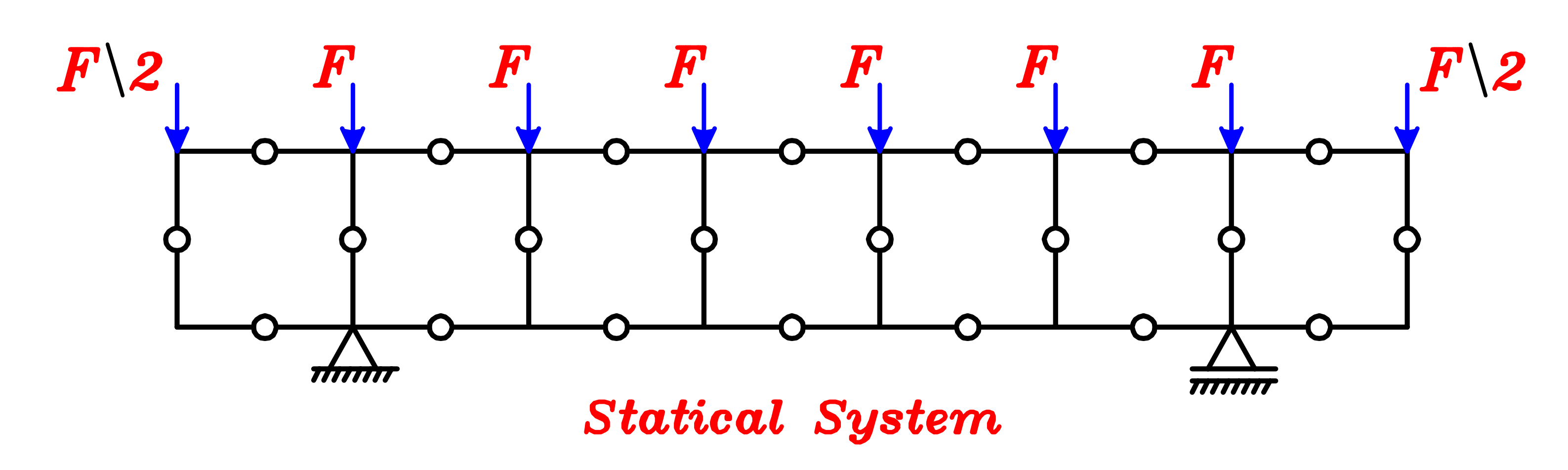
One Way Slab

$t \simeq \frac{L}{20}$

$h = \frac{L}{6 \to 8}$

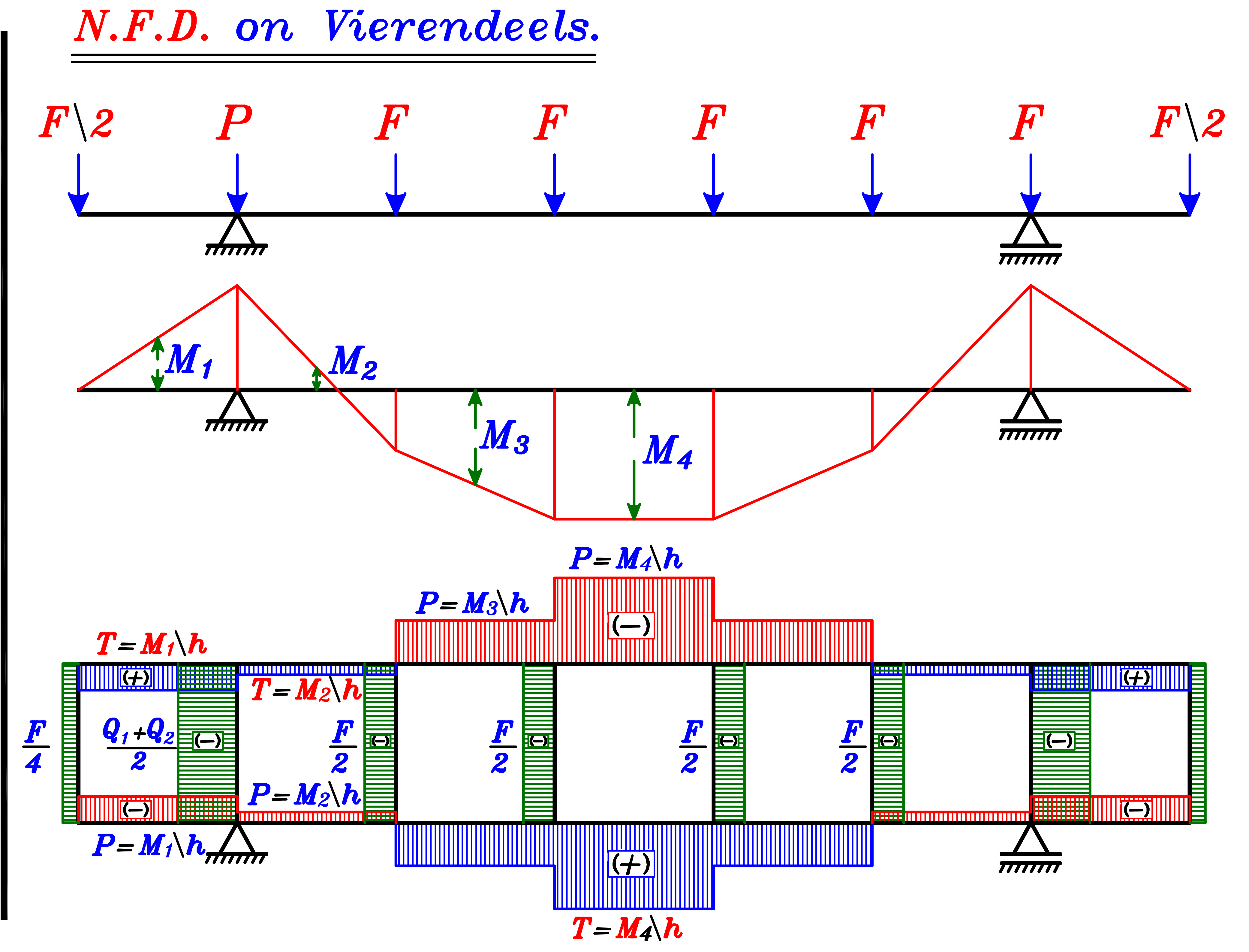
$a \simeq h$

$L = (15 \to 40)\, m$



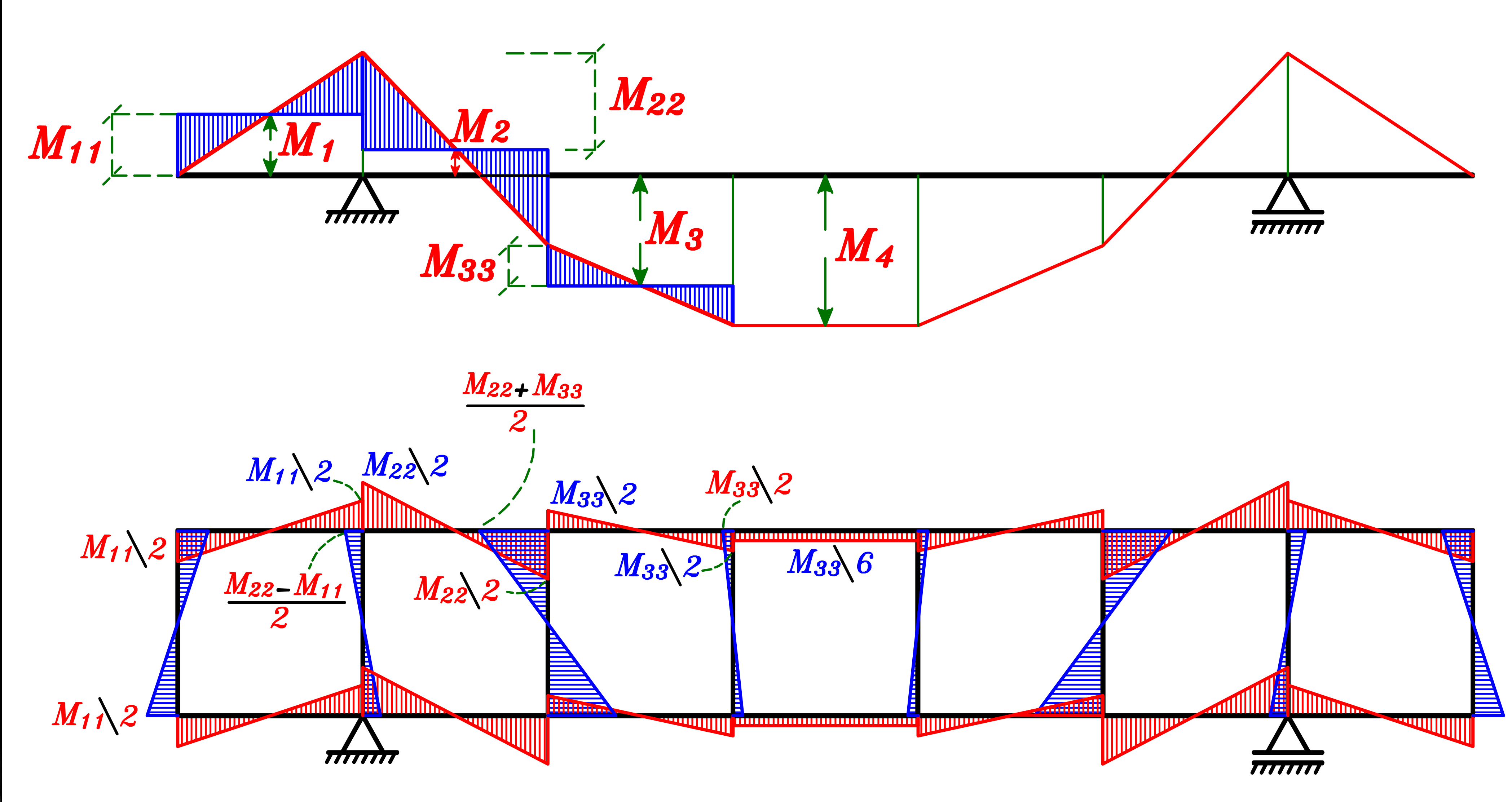
Statical System

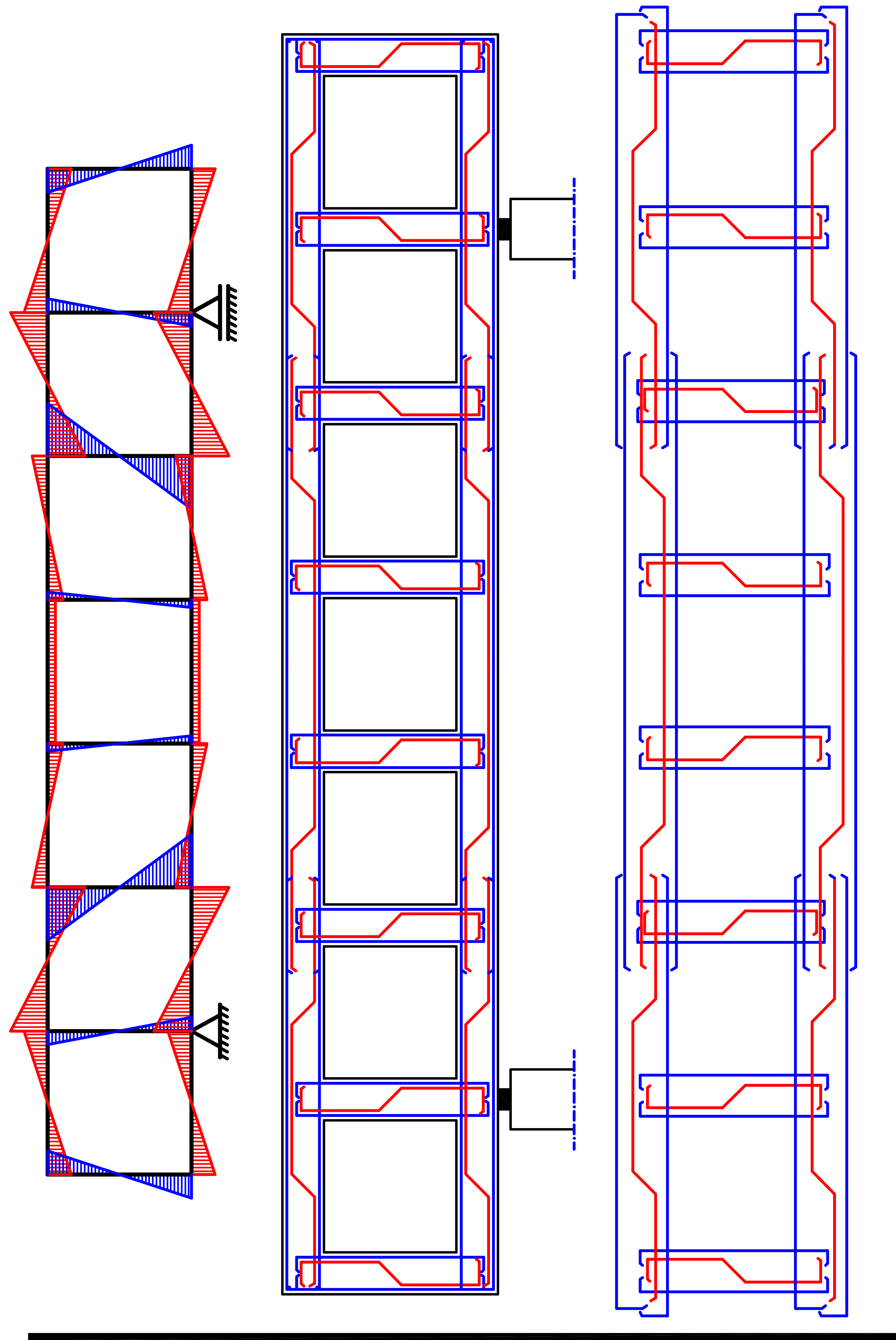
S.F.D. on Vierendeels.



N.F.D. on Vierendeels.
F\2
P
F
F
F
F
F
F\2
M_1
M_2
M_3
M_4
$P=M_4\backslash h$
$P=M_3\backslash h$
$T=M_1\backslash h$
$T=M_2\backslash h$
$P=M_2\backslash h$
$P=M_1\backslash h$
$T=M_4\backslash h$
$\frac{F}{4}$
$\frac{Q_1+Q_2}{2}$
$\frac{F}{2}$
(+)
(−)

B.M.D. on Vierendeels.





Vierendeel with cantilever.

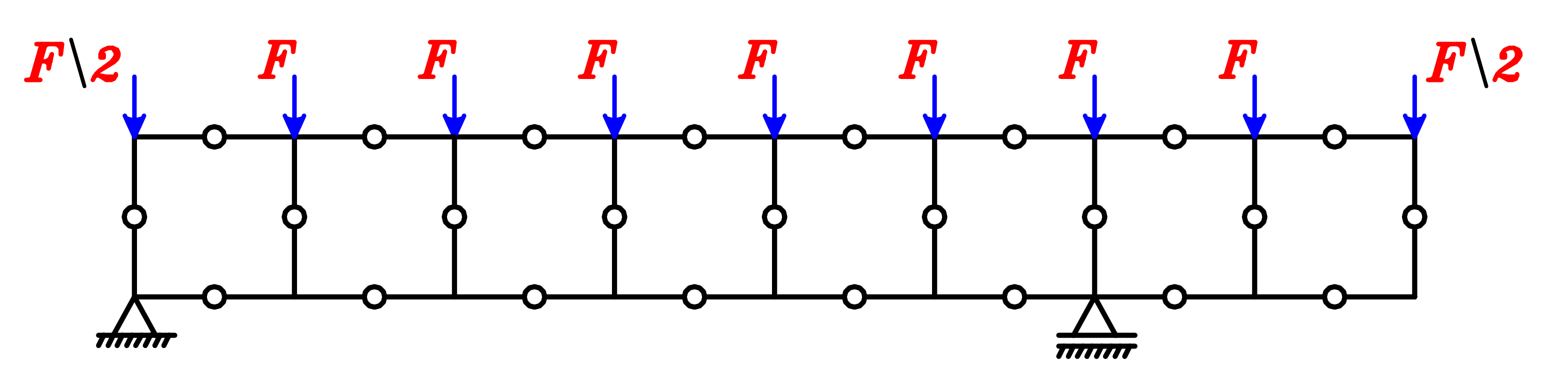
One Way Slab

$t \simeq \frac{L}{20}$

$h = \frac{L}{6 \rightarrow 8}$

$a \simeq h$

$L = (15 \rightarrow 40)\ m$



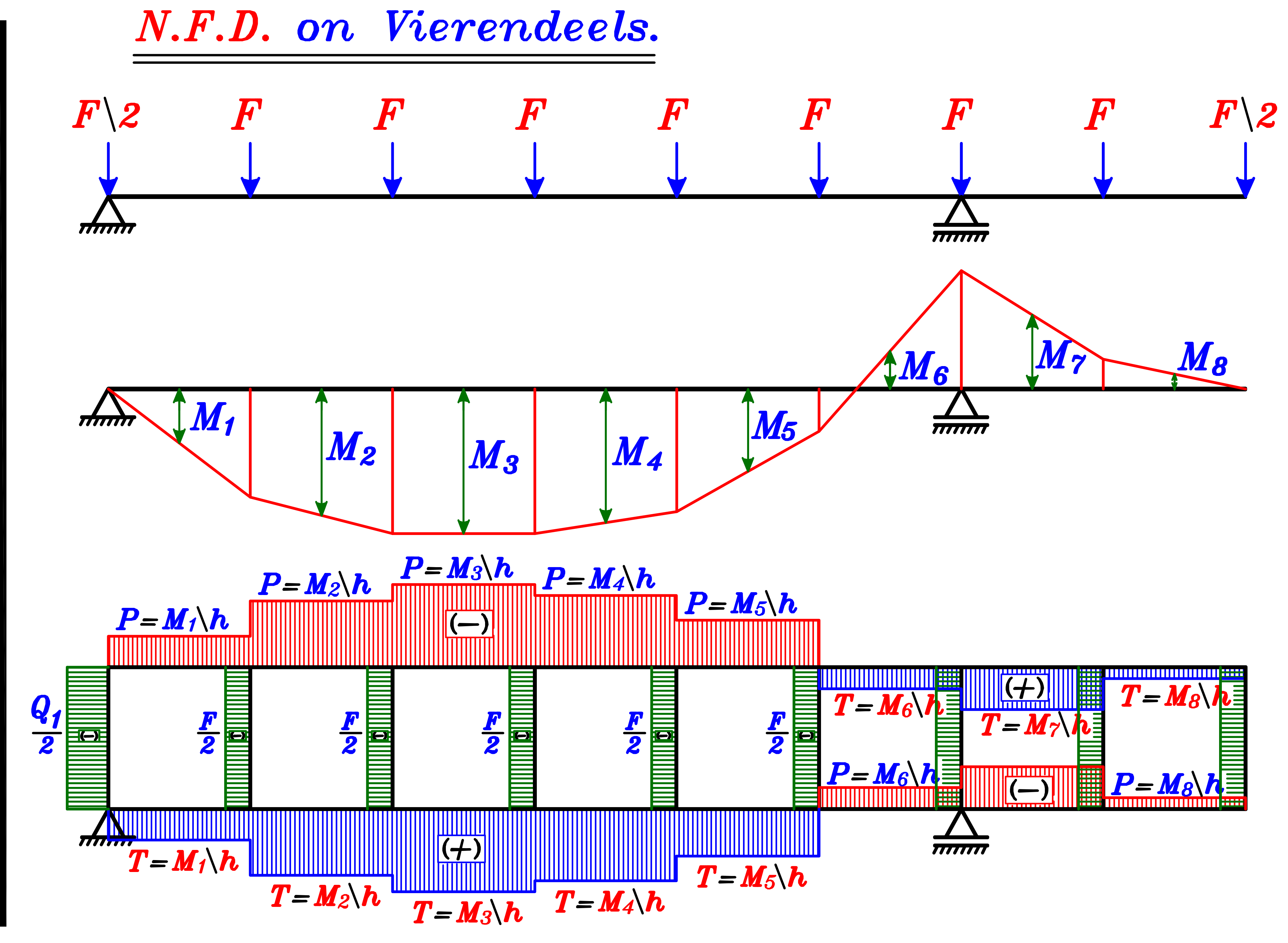
Statical System

S.F.D. on Vierendeels.

F\2 F F F F F F F F\2

Q_1 Q_2 Q_3 Q_4 Q_5 Q_6 Q_7 Q_8

$Q_1\backslash 2$ $Q_2\backslash 2$ $Q_3\backslash 2$ $Q_4\backslash 2$ $Q_5\backslash 2$ $Q_6\backslash 2$ $Q_7\backslash 2$ $Q_8\backslash 2$



N.F.D. on Vierendeels.
F\2
F
F
F
F
F
F
F
F\2
M1
M2
M3
M4
M5
M6
M7
M8
P=M1\h
P=M2\h
P=M3\h
P=M4\h
P=M5\h
(−)
Q1/2
F/2
F/2
F/2
F/2
F/2
T=M6\h
T=M7\h
T=M8\h
(+)
P=M6\h
(−)
P=M8\h
(+)
T=M1\h
T=M2\h
T=M3\h
T=M4\h
T=M5\h

B.M.D. on Vierendeels.

